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Description of the Cerro Grande Fire Orthophotography Data Set

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by

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ABSTRACT

Electronic orthophotos were taken of the Pajarito plateau region following the Cerro Grande Fire. A preliminary quality assurance analysis of the orthophotos has been conducted that provides details of the accuracy and quality of the imagery. The images are now available to authorized personnel through Facility for Information Management, Analysis, and Display (FIMAD). This document provides metadata for the orthophoto data set.

Introduction

Background. Following the Cerro Grande Fire, LANL (the Environmental Restoration Project and ESH Division) contracted with Merrick & Co. to provide an aerial photography and orthophoto survey of the Pajarito Plateau region. The survey was conducted to assist with analyses of fire severity, fire remediation, and flooding hazards. Details of the aerial photography mission are as follows.

- Flight Dates: June 13 and 14, 2000
- Flight Region: approximately 320 square miles
- Flight Altitude: approximately 12,000 ft. above mean terrain
- Aerial photography at a photo negative scale of 1-inch = 2000 ft.
- Photography conducted in a region bounded by Cochiti Reservoir (south), by Santa Clara Canyon (north), by Valles Caldera Divide (west), and by the Rio Grande (east)

Project Funding**.** The orthophotography contract and subsequent data stewardship activities have been supported by

- The Environmental Restoration Project—coordinated by Diana Hollis
- The Environment, Health, and Safety Division—coordinated by Steve Rae

Orthophotography**.** The aerial photography was orthorectified by Merrick & Co. (i.e., the images were orthographically projected in a distortion-free manner onto topography) using a LIDAR-derived digital elevation model. The resulting orthophotos are a digital product with the following characteristics (see Figure 1 for a map of the tiling scheme).

- Orthophoto: 2 ft. pixel (1-inch = 400 ft. at 200 dpi)
- Orthophoto tiling scheme: The ortho images are available on 477 tiles, 6,000 ft. (east-west) by 4,000 ft. (north-south) which is 3,000 by 2,000 pixels
- Orthophoto naming scheme:
  Example name: op724588_002b.tif

op: orthophoto
724588: lower-left corner of image is located at
1,724,000 ft. northing and 1,588,000 ft. easting
002: 2 ft. pixel
b: Cerro Grande Fire (2000) data set

- Orthophoto cell centering:
  Example tile: op724588_002b.tif
  The outside corner of the lower-left cell is located at 1,724,000 ft. (northing), 1,588,000 ft. (easting) (i.e., the center of the lower-left cell is located at 1,724,001 ft., 1,588,001 ft.)
- Orthophoto Format: tiff world format
- Orthophoto Projection: New Mexico State Plane feet using the NAD-83 horizontal datum and the NGVD-29 vertical datum

LANL Data Steward Activities**.** The data stewards at LANL for the orthophoto are Bill Carey, Greg Cole, Bob Beers, and Steve Lloyd. The primary roles of the data stewards are as follows (see the following pages for a report of these activities).

- Develop the contract for aerial photography and orthophoto services
- Ensure that contract was completed satisfactorily
- Inventory and archive data
- Conduct QA analyses of image quality
- Conduct QA analyses of image positional accuracy
- Provide copy for electronic distribution
- Ensure metadata for the orthophotos are in compliance with established FGDC standards
- Create LA-series report documenting the data set

Quality Assurance Report

This report details the primary responsibilities and current status of quality assurance (QA) activities conducted by the data stewards for the aerial photography and orthophoto project.

Development of Contract Specifications

Completed in June 2000. See Appendix 1 for a copy of the contract. The primary contract specifications were as follows.

- Create a network of ground-based reference points to be used in the aerotriangulation of the aerial photography
- Take aerial photographs using natural color film at a negative scale of 1-inch = 2000 ft. from a flying altitude of approximately 12,000 ft. above mean terrain
- Aerial photographs shall meet all precision requirements for aerotriangulation and GIS database compilation conforming to the USGS Map Accuracy Standards.
- Perform Fully Analytical Aerotriangulation (FAAT) to merge ground control and aerial photography
- Scan the aerial photography negatives to create digital representation of images
- Orthorectify the images to a 2 ft. pixel resolution

- Color balance the images to produce a “seamless” image database across the entire project
- Provide orthophotos to a specified tiling scheme.
- Provide a color mosaic of entire region

Contract Completion

All contractual obligations for aerial photography and orthophotos have been completed. The aerial photography mission was accomplished with the following conditions:

- Flight Dates: June 13 and 14, 2000
- Flight Region: approximately 320 square miles
- Flight Altitude: approximately 12,000 ft. above mean terrain
- Aerial photography at a photo negative scale of 1-inch = 2,000 ft.
- Photography conducted in a region bounded by Cochiti Reservoir (south), by Santa Clara Canyon (north), by Valles Caldera Divide (west), and by the Rio Grande (east)

Inventory and Archive of Data

1. The aerial photography prints were delivered as sets of photos taken along 12 flight lines. The flight lines were oriented N–S and were arranged from W–E.

Flight Line	Number of Photos	Notes
1	16	photo #16 skipped, photo 17 present
2	28	
3	26	
4	26	
5	26	
6	27	
7	30	
8	20	
9	21	
10	18	
11	19	
12	21	
Total	278	

2. Orthophotos were generated from the aerial photography using digital elevation data obtained from the 2000 LIDAR survey of the same region. The elevation data were obtained as a sub-sampled set of raw data from the LIDAR survey (i.e., the elevation data were not obtained from the LIDAR digital elevation model). The orthophotos have the following characteristics:

- Resolution: 2 ft. pixel (1-inch = 400' at 200 dpi)
- Tiling scheme: The orthophotos are available on 477 tiles, 6,000 ft. (easting) by 4,000 ft. (northing) which is 3,000 by 2,000 pixels
- Orthophoto naming scheme:
  Example name: op724588_002b.tif

op: orthophoto
724588: lower-left corner of image is located at
1,724,000 ft. northing and 1,588,000 ft. easting
002: 2 ft. pixel
b: year 2000 data set

- Orthophoto coverage (see Figure 1)
- Orthophoto cell centering:
  Example tile: op724588_002b.tif
  The outside corner of the lower-left cell is located at 1,724,000 ft. (northing), 1,588,000 ft. (easting) (i.e., the center of the lower-left cell is located at 1,724,001 ft., 1,588,001 ft.)
- Orthophoto Format: tiff world format
- Orthophoto Projection: New Mexico State Plane feet using the NAD-83 horizontal datum and the NGVD-29 vertical datum

Two sets of orthophotos were delivered on CD-ROMs, each consisting of 477 tiles. The two sets differ in the color balance (see discussion below). The tiles were inventoried and their location is graphically represented in Figure 1. The outside curvilinear boundary of the figure shows the area specified by the contract. The orthophotos were copied to computer disk to provide a readily available copy of the data.

3. Because of issues with respect to color and contrast in the orthophotos (see below), the contractor was asked to provide the orthorectified data for the individual photographs prior to color-balancing and tiling of the data. This third data set provides the basis for image analysis activities should they be desired. There are 137 orthorectified non-color-balanced images (about ½ of the total number of photos) and each image captures approximately the central 50% of the photo.

QA Analyses of Image Quality

The quality of the aerial photographs varied along flight lines and between flight lines.

- Some photos appeared to have low contrast (i.e., making it difficult to identify low-burn intensity areas on some photos)—For example, photo 5-17
- Sun spots (due to refraction of the sun on the aircraft) created bright spots (usually in the NW region of the photos) and darkened, lower contrast areas (usually in the SE region of the photos)—For example, photo 4-19
- Color balance varied in the photos (some photos appeared to be over-saturated in green-yellow tones)—For example, compare photos 7-26 and 8-15

Perhaps for these reasons, the color-balanced orthophotos derived from the aerial photographs have a green-yellow hue and have relatively low contrast. Extensive investigation of the color balance in the orthophotos (i.e., by analysis of RGB histograms) indicates that the images are deficient in blue and that the contrast (as indicated by the histogram range) is somewhat low.

These features of the orthophotos are a consequence, in part, of the contract-specification that the mosaic of the orthophotos should be seamless and color-balanced. In order to address these issues, a second set of orthophotos was developed with

enhanced blue intensity and a third set of non-color-balanced, non-tiled ortho-rectified images was obtained.

It should be noted that the contrast and color-balance of individual tiles could be easily enhanced with standard software. In the future, a modified orthophoto set may be developed by application of the same contrast-enhancement to the entire data set or by a global reanalysis of the non-color-balanced images to produce an alternative seamless mosaic.

QA Analyses of Positional Accuracy

The contract specification for positional accuracy stated that the orthophotos must meet national map standards. These standards are 1/50-inch at map scale. The images were produced at 1-inch = 400 ft. scale, which requires that 90% of the image has better than 8 ft. accuracy.

The positional accuracy of the orthophotos was characterized by the Fully Analytical Aerotriangulation (FAAT) report provided by the contractor (Appendix II). The FAAT report contains a statistical summary of the positional accuracy of the controls used to fix the positions of the aerial photographs. A total of 47 ground-surveyed control points was used in the FAAT. Of these, 33 provided elevation control and 14 provided horizontal and elevation control. The positional accuracy of these controls is shown in Table 1.

Table 1. Positional accuracy of ground-control points and aerial photo centers used in the generation of the orthophotos expressed as root-mean-square error in feet (Appendix II).

	X-coordinate	Y-coordinate	Z-coordinate
Survey-control	0.9891	0.7910	0.3697
Aerial photo centers	1.120	1.162	0.823

As a supplementary QA of positional accuracy, the positions of objects in the orthophotos were compared to positions determined from the 1992 orthophoto data set (Cole 1993). The older data set was collected at 1-inch = 100 ft. scale and had an accuracy of 90% of the data better than 1.6 ft., as characterized by Cole (1993). The positions were compared by picking identical locations off each orthophoto (e.g., the corner of a building) and calculating the difference in feet. In addition to the inherent errors in each data set, there were additional errors introduced through imprecision in identifying the precise position of features in the orthophotos. These errors were on the order of 1 ft. (1 pixel) in the 1992 survey and 2 ft. (1 pixel) in the orthophotos under consideration. The results of this comparison are given in Table 2 (see end of paper). In addition, 4 objects from the 1993 Geonex survey were identified on the 2000 orthophotos, and distances between the GPS-surveyed Geonex data and the 2000 orthophotos were determined.

In sum, there were 90 measurements of positional accuracy (see Figure 2 for the location of these measurements). The cumulative frequency of these data is illustrated in Figure 3. The average and standard deviation of the differences are 4.54 and 2.07 feet. Figure 3 shows that 92% of the measured data are better than 8 ft. and a statistical model based on the measured standard deviation—assuming a Gaussian distribution of errors—predicts that 90% of the data are better than 7.2 feet. A 95%

confidence level maximum value of the standard deviation (determined by chi square statistics) is 2.31. Using this standard deviation, 90% of the data are better than 7.5 feet.

It should be noted that we were unable to make QA comparisons in the most northern and southern parts of the survey (Figure 2). Such measurements could be made in the future by using a GPS unit to locate orthophoto identifiable objects.

Electronic Distribution of Data

The orthophotos are available through the EES Division GIS Laboratory, FIMAD, or by contacting the authors.

Create Documentation of the Data Set

This report may be cited in documents using the orthophoto or aerial photography results.

Reference

Cole (1993): "Quality Report–ER aerial survey and resultant orthophoto and digital contour data" A memorandum from Greg Cole (EES-1) to Record Processing Facility for the ER Project dated September 30, 1993.

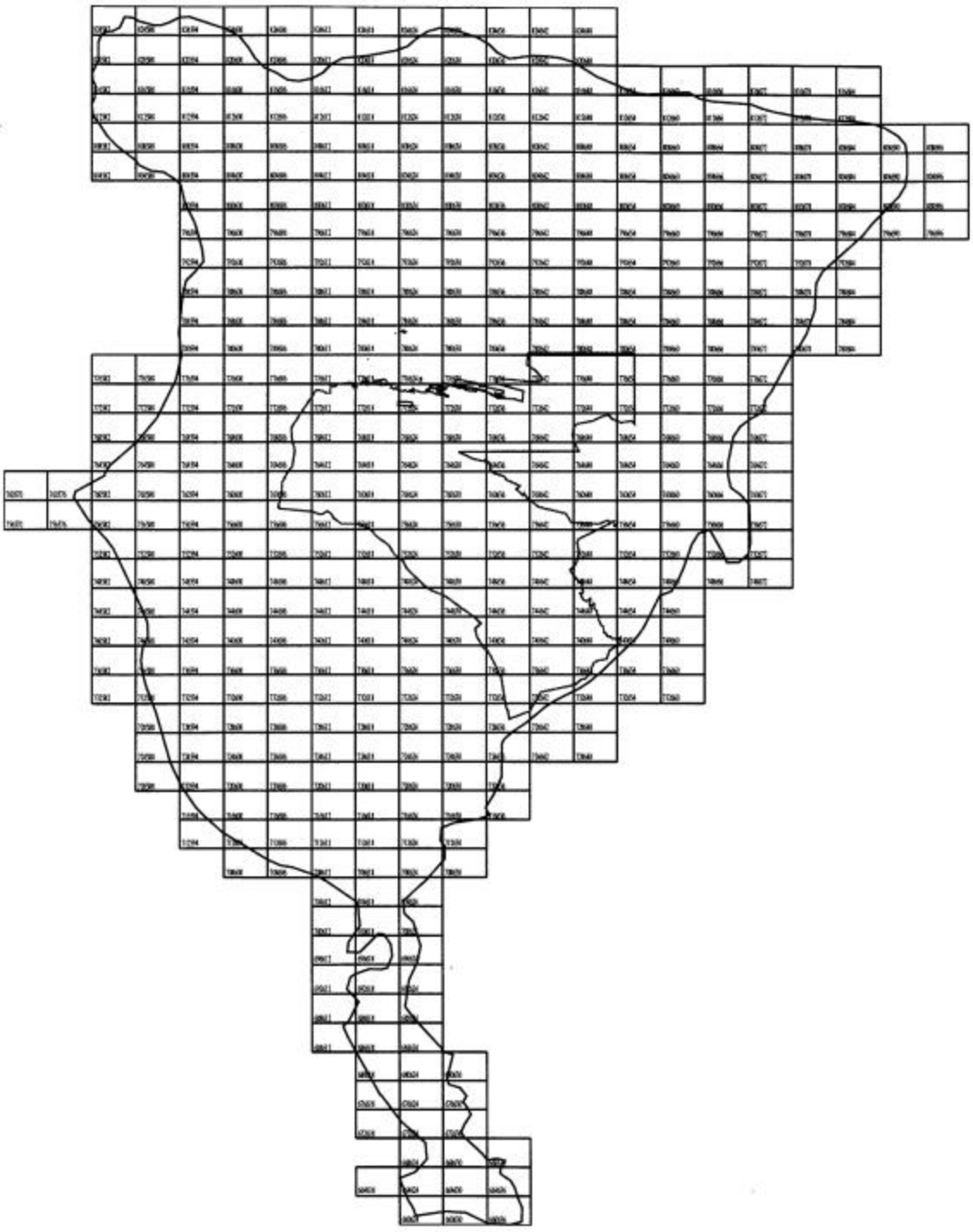


Figure 1. A map showing the geographic distribution of the orthophoto tiles. The Los Alamos National Laboratory boundary is shown in the center of the figure. The curve near the outside of the figure defines the study area as specified in the orthophoto contract (Appendix I).

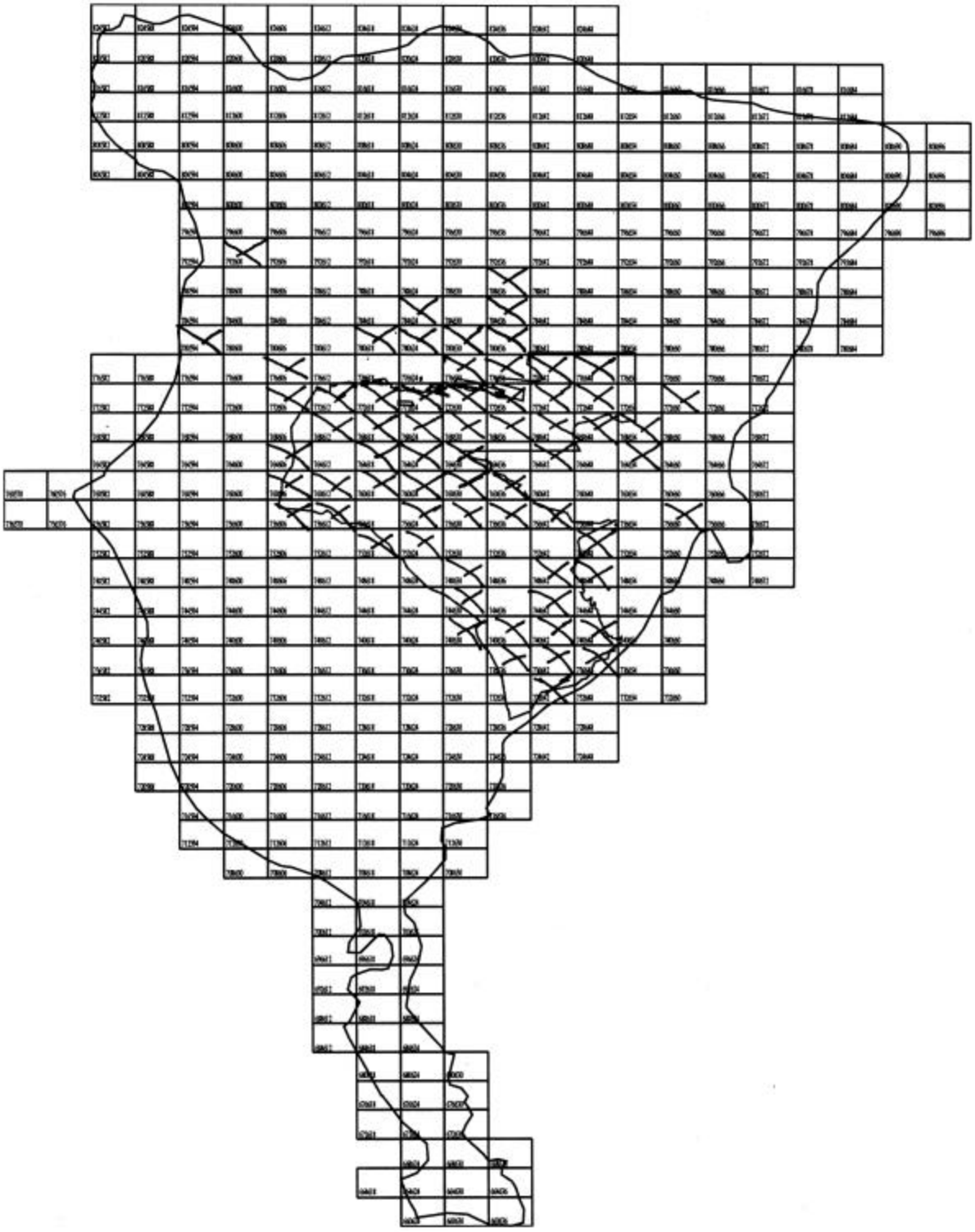


Figure 2. The orthophoto tiles marked with “X” were examined for positional accuracy in the quality assurance study (see results in Table 1).

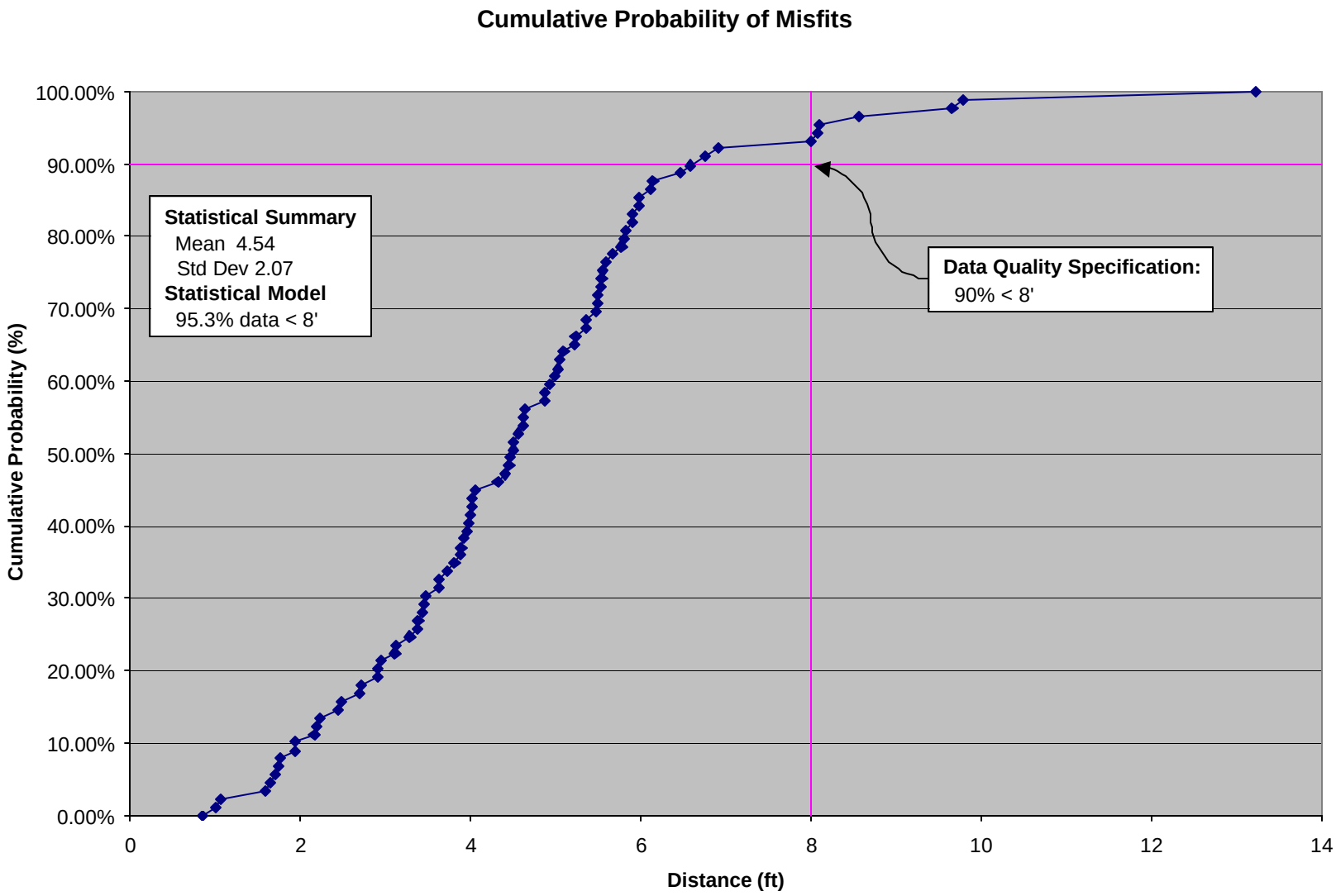


Figure 3. Cumulative probability plot showing the absolute value of the misfit between measurements made on the 1992 ortho-photo survey and the 2000 orthos survey. The measured probability distribution satisfies the data quality specification.

Table 2. Measured distances between objects in 1992 ortho survey and objects in the 2000 ortho survey (86 measurements) and measured distances between objects in Geonex survey (1993) and the 2000 ortho survey (4 “Geonex” measurements).

1992 Survey		2000 Survey		del X	del Y	dist	Description
x1 (feet)	y1 (feet)	x2 (feet)	y2 (feet)				
1616521.9	1763813.5	1616525.0	1763808.9	–3.099	4.530	5.489	TA-16 Air Heater, 16-402, inside (SE) corner of V-shaped structure south of building
1612950.9	1760465.4	1612955.1	1760464.0	–4.206	1.461	4.453	TA-16 Storage Building, 16-414, white building inside SW facing corner
1613783.4	1761664.7	1613786.9	1761665.1	–3.446	–0.368	3.466	TA-16 Storage Building, 16-414,SW corner of small bldg adjacent to long white bldg
1624476.0	1759393.1	1624476.6	1759385.0	–0.640	8.070	8.095	Building north of TA-15 DARHT Facility, SE corner of east-side building addition
1626717.6	1758577.2	1626714.4	1758573.3	3.178	3.849	4.991	Trailer(?) north of TA-15 Power Control Building, building 15-185
1635058.6	1749880.9	1635056.7	1749876.9	1.825	3.913	4.318	NE corner of trailer at end of road NW of TA-39 Equipment Shelter, bldg 39-64
1638709.0	1740278.7	1638708.0	1740286.7	0.969	–8.027	8.085	SE corner of TA-33 Machine Shop, bldg HP-39
1639976.3	1742602.6	1639982.9	1742597.2	–6.645	5.391	8.557	SW corner of TA-39 Branch Shops Building, bldg 39-98
1646210.8	1736363.2	1646213.6	1736360.3	–2.817	2.921	4.058	SE corner of TA-33 Bunker, bldg HP-151
1647969.3	1750343.7	1647966.4	1750345.2	2.897	–1.553	3.287	S corner of house near intersection of Rd to Bandelier and Monte Rey Drive South
1642080.4	1757303.8	1642085.4	1757303.7	–5.027	0.168	5.030	SE corner of TA-36 Backflow Preventer, bldg 36-136
1644666.2	1757652.9	1644666.2	1757648.0	–0.039	4.921	4.921	Utility pole at SW end of TA-54 Tension Support Building, bldg 54-48
1639825.4	1759293.7	1639831.7	1759286.2	–6.257	7.529	9.790	SE corner of TA-54 Canopy and Pad, bldg 54-32
1641736.5	1758637.7	1641737.0	1758633.1	–0.506	4.593	4.621	SE corner of TA-54 Metal Shed, bldg 54-25
1636061.8	1760982.0	1636064.6	1760975.7	–2.804	6.312	6.907	SE corner of TA-18 Guard Station #450, bldg PL-190
1634639.2	1760521.3	1634638.4	1760515.9	0.827	5.436	5.499	SE corner of fence around TA-18 Critical Assembly Building, bldg PL-32
1635685.2	1762902.3	1635682.2	1762897.3	2.990	4.996	5.822	SW corner of fence around TA-54 Tru-Waste NDA/NDE, bldg 53-38
1631984.0	1757347.3	1631981.0	1757345.3	3.029	2.002	3.631	SE corner of trailer(?) SE of TA-36 Meenie Preparation Building, bldg KAPPA-05
1635450.4	1759560.6	1635448.0	1759555.1	2.406	5.471	5.977	Fence-drive intersection at SE fence-line of TA-36 Security Precinct Facility, bldg KAPPA-69

1992 Survey		2000 Survey		del X	del Y	dist	Description
x1 (feet)	y1 (feet)	x2 (feet)	y2 (feet)				
1626092.3	1763162.4	1626090.3	1763159.6	2.035	2.770	3.437	SW corner of TA-15 Laboratory Building, bldg R-263
1627066.6	1761870.7	1627066.4	1761857.5	0.250	13.225	13.227	SE corner of unnamed building SE of TA-15 Mineral Oil Tank, bldg 15-325, on the east side of road
1622637.1	1761207.6	1622634.1	1761204.2	2.928	3.358	4.455	SW corner of TA-15 Portable Shed, bldg 15-376
1618424.3	1760370.3	1618422.7	1760368.8	1.582	1.511	2.188	Crack junction around "pond" feature at TA-11 Drop Tower, 11-25
1623240.1	1762833.8	1623235.8	1762830.8	4.244	3.056	5.230	SW corner of A-15 Laboratory Storage Building, R-23
1614914.6	1768680.0	1614918.5	1768682.1	–3.892	–2.052	4.400	SW corner of TA-22 Storage Building, bldg TD-68
1616774.7	1768143.8	1616773.2	1768142.8	1.445	0.985	1.749	Fence bend west of TA-40 Magazine, bldg DF-40
1614162.7	1770275.1	1614163.0	1770273.0	–0.281	2.144	2.162	NE end of painted white triangle on road south of TA-06 Booster Station # 2, bldg 06-63
1619967.8	1767213.9	1619966.5	1767207.3	1.326	6.617	6.749	SE corner of fence (lot?) south of TA-40 Preparation and Utility Building, bldg DF-11
1620359.4	1764053.8	1620354.0	1764053.6	5.358	0.183	5.361	SW corner of TA-14 Storage Building, bldg Q-06
1627453.5	1767325.9	1627450.8	1767322.2	2.683	3.690	4.562	Western end of painted traffic triangle east of TA-66 Atac Office Building, bldg 66-01
1630275.8	1765909.4	1630274.0	1765906.0	1.817	3.428	3.880	Western inside corner of sidewalk junction along parking lot east of TA-46 Technical Support Facility, bldg 46-326
1631160.6	1767950.3	1631160.4	1767944.8	0.210	5.536	5.540	NW fence corner surrounding TA-05 Switchgear Vault and other buildings, bldg 05-23
1617307.5	1772525.6	1617307.7	1772526.4	–0.217	–0.823	0.851	SW corner of TA-03 Geochemistry Analytical Facility, bldg SM-494
1616834.4	1773735.7	1616834.3	1773737.4	0.048	–1.651	1.652	S corner of TA-03 Warehouse, bldg SM-142
1609696.8	1762845.0	1609700.1	1762844.8	–3.375	0.257	3.385	NE corner of A-16 Transportable Office Building, bldg 16-246
1609449.3	1760791.4	1609449.8	1760793.3	–0.507	–1.865	1.933	SE corner of TA-16 Tritium Processing Facility, bldg 16-205
1624013.6	1755155.6	1624014.1	1755152.2	–0.511	3.331	3.370	SE corner of TA-49 Explosives Magazine, bldg FM-114
1632769.4	1744704.4	1632765.0	1744699.4	4.358	4.926	6.577	SW corner of gate building at entrance to Bandelier National Park
1615613.7	1759546.8	1615618.9	1759545.3	–5.144	1.485	5.354	SW corner of TA-16 HE Inspection Building, bldg 16-380
1610172.4	1767387.1	1610173.3	1767389.4	–0.899	–2.266	2.438	SW corner of TA-08 Isotope Building, bldg AW-24
1611160.7	1764882.5	1611164.0	1764879.4	–3.237	3.118	4.494	Inside SE corner of T-intersection of white linear buildings part of TA-16 X-Ray Building, bldg 16-220
1643917.4	1743503.5	1643914.7	1743498.3	2.645	5.162	5.800	Small bush at intersection of trails

1992 Survey		2000 Survey		del X	del Y	dist	Description
x1 (feet)	y1 (feet)	x2 (feet)	y2 (feet)				
1650018.6	1736096.8	1650024.0	1736094.3	–5.325	2.549	5.904	Boulder on west bank of Rio Grande at southern edge of tile
1643244.9	1747821.0	1643244.7	1747815.0	0.208	5.979	5.983	Small tree in clearing south of road/trail in Northeast corner of tile
1633394.2	1778791.2	1633395.7	1778796.7	–1.465	–5.583	5.772	NE corner of porch on 1106 Big Rock Loop
1630324.7	1779668.8	1630327.1	1779668.6	–2.461	0.292	2.478	Inside corner of sidewalk at San Ildefonso Road and Broadview Drive
1618289.4	1780340.7	1618287.3	1780337.3	2.121	3.346	3.962	SW corner of fence surrounding Urban Park tennis courts
1623630.1	1782904.1	1623627.5	1782901.1	2.673	2.941	3.974	W corner of golf course swimming pool
1625024.1	1785304.0	1625021.3	1785299.1	2.794	4.924	5.661	Monument in center of circle at NW corner of cemetary
1629981.4	1785336.9	1629977.2	1785333.2	4.203	3.693	5.595	Left edge of white E–W structure on north side of turnoff to east from Rendija Road
1640902.3	1789313.7	1640899.3	1789311.1	2.986	2.678	4.011	Center of bush south of where two track dirt road crosses draw
1652666.1	1779861.7	1652670.0	1779857.7	–3.870	3.974	5.547	Clearing in center of clump of trees at horseshoe bend in dirt road
1609587.3	1776855.2	1609583.6	1776859.3	3.704	–4.102	5.527	Opening in west end of wharf on east side of reservoir
1655472.1	1768213.3	1655470.5	1768209.7	1.580	3.552	3.888	Small bush on west bank of arroyo just before horseshoe bend
1654318.6	1760500.1	1654318.3	1760498.2	0.371	1.900	1.936	Intersection of line of bushes extending SSW from large tree and north edge of 2-lane dirt track
1659971.9	1748015.3	1659973.9	1748010.2	–1.936	5.123	5.477	Closest complete bush to SE corner of sheet
1650788.7	1741555.8	1650791.5	1741552.1	–2.770	3.713	4.632	Smaller bush just east of larger tree which is part of a triad
1643117.3	1735809.4	1643120.5	1735804.2	–3.254	5.183	6.120	Isolated bush
1631808.9	1743856.1	1631800.5	1743851.3	8.348	4.860	9.660	SW corner of building with white roof
1620582.6	1749322.9	1620580.1	1749317.6	2.547	5.324	5.902	Center of elliptical bush
1607532.4	1759045.7	1607531.8	1759046.6	0.613	–0.860	1.056	Center of guard post at back gate
1606585.6	1765487.9	1606583.0	1765491.8	2.547	–3.860	4.625	Intersection of trail with horseshoe curve on dirt road
1611815.8	1773053.3	1611818.7	1773052.1	–2.903	1.135	3.117	Edge of bank on north side of ski hill turnoff
1632770.4	1744704.9	1632767.0	1744703.8	3.433	1.175	3.629	South corner of BNM entrance booth
1637093.4	1736627.0	1637095.4	1736623.6	–1.965	3.390	3.918	North end of highway stripe
1632340.3	1780831.8	1632335.2	1780830.7	5.124	1.054	5.231	North corner of fence around rodeo grounds
1662259.2	1757673.1	1662259.1	1757671.5	0.130	1.699	1.704	Middle of large boulder
1642699.3	1764666.1	1642696.4	1764666.6	2.869	–0.477	2.908	Small tree with horseshoe bend of arroyo

1992 Survey		2000 Survey		del X	del Y	dist	Description
x1 (feet)	y1 (feet)	x2 (feet)	y2 (feet)				
1648716.4	1752459.6	1648718.7	1752458.1	–2.287	1.457	2.712	Center of sidewalk on north side of Piedra Loop
1644597.1	1772893.4	1644593.7	1772890.4	3.375	2.983	4.504	Small tree by dirt track
1636330.9	1768430.6	1636330.2	1768429.0	0.719	1.614	1.767	8-foot diameter rock
1631785.0	1772168.5	1631784.0	1772168.3	0.997	0.138	1.007	Base of pole
1636752.2	1775181.2	1636756.2	1775180.4	–3.950	0.723	4.016	Wind post with circle
1625039.3	1769255.3	1625037.5	1769254.0	1.795	1.308	2.221	Intersection of curb and sidewalk
1620047.4	1773303.4	1620047.6	1773297.0	–0.258	6.451	6.456	Bend in fence south of gate
1618622.5	1769057.6	1618622.3	1769052.5	0.149	5.093	5.095	Center of low-lying circular feature
1624397.7	1773508.7	1624401.6	1773501.8	–3.953	6.960	8.004	NW corner of concrete pad
1650752.1	1772095.1	1650755.6	1772091.4	–3.414	3.713	5.044	SW corner of white feature
1630918.9	1768436.1	1630918.0	1768433.6	0.949	2.517	2.690	Center 10 x 6-foot concrete structure
1643657.4	1768220.3	1643658.6	1768215.6	–1.145	4.735	4.871	Outcrop between trees
1649029.0	1768903.7	1649030.0	1768897.6	–0.976	6.064	6.142	Small bush in arrow south of cliff apex
1642972.0	1776709.0	1642971.4	1776705.3	0.676	3.750	3.810	Center of small NE tank
1638008.0	1784131.2	1638008.8	1784128.3	–0.719	2.851	2.940	Small tree east of larger stand
1626265.8	1780327.3	1626264.8	1780326.1	1.003	1.224	1.582	NW corner of tennis court
1637978.4	1776626.4	1637977.9	1776621.5	0.456	4.848	4.869	Boulder in field
1638316.1	1781495.0	1638318.8	1781492.4	–2.664	2.609	3.729	East edge of driveway
1596812.3	1781856.8	1596812.9	1781854.0	–0.642	2.845	2.917	Geonex survey point
1661957.0	1774108.9	1661953.9	1774109.1	3.105	–0.206	3.112	Geonex survey point-note: NE corner of cattle guard instead of SE (cattle guard aligned SW–NE)
1635370.9	1803020.6	1635369.7	1803016.8	1.194	3.810	3.993	Geonex survey point-faint footprint of 25 x 25 foot square object aligned N–S
1600840.1	1792796.7	1600842.6	1792794.3	–2.491	2.389	3.451	Geonex survey point
Summary Statistics			max	8.348	13.225	13.227	
			min	–6.645	–8.027	0.851	
			average	0.086	2.658	4.544	
			std dev	2.903	3.094	2.067	

APPENDIX I

Statement of Work for Aerial Photography and Orthophotography Contract

STATEMENT OF WORK

PHOTOGRAMMETRIC AND LIDAR AERIAL MISSIONS

FOR

SUPPORT OF THE CERRO GRANDE FIRE DISASTER

Environmental Restoration Project
Environment, Safety & Health Division

I. Introduction

ESH Division and the ER Project propose to conduct photogrammetric and LIDAR aerial missions over approximately 321 square miles of Los Alamos National Laboratory, Los Alamos County, Bandelier National Monument, Santa Fe National Forest, Santa Clara Pueblo, the Pueblo of San Ildefonso, and Cochiti Pueblo in order to accurately document, inventory, model, and analyze the existing and potential damages resulting from the recent Cerro Grande fires. The services required are as follows:

- Low resolution LIDAR data acquisition for approximately 173 square miles (A & C of attached map);
- High resolution LIDAR data acquisition for watershed and drainage study area approximately 148 square miles (Area B of attached map);
- Color aerial photography at a scale of 1"=2,000' for approximately 321 square miles (Areas A, B, & C of attached map) to support 1"=400' digital ortho imagery;
- Analysis of LIDAR data to produce "bare-earth" DEMs, reflectance, and canopy data; and
- Creation of ortho imagery from aerial photography and DEMs.

II. Mapping Area

The attached map illustrates the extent of the mapping area. The map also shows the 1"=400' tiles using a 12,000 x 8,000' grid. The polygon indicates the extent of the Cerro Grande fire.

Areas A, B, and C on the attached map reference the following study areas:

- A and C: Areas of low-resolution LIDAR, approximately 173 square miles;
- B: Area of high-resolution LIDAR, approximately 148 square miles; and
- A, B, and C: Areas of 1"=400' color ortho imagery, approximately 321 square miles.

III. Services and Specifications

The primary services required under this statement of work are as follows:

A. Aerial Photography

Photography is the source for collecting event (fire damage), physical, and cultural features as they are represented at the time of exposure.

1. Aerial photography shall be flown using natural color film at a negative scale of 1"=2,000' (1:24,000) sufficient to support 1"=400' digital ortho imagery. The flying altitude shall be approximately 12,000' above mean terrain.

2. All aerial photography shall be accomplished as to afford photographs meeting all precision requirements for aerotriangulation and GIS database compilation conforming to the USGS Map Accuracy Standards. These standards include:

   - flying under optimal weather conditions such as cloud coverage and sun angle (there may be smoke/haze),
   - Federal Aviation Administration (FAA) and Civil Aeronautics Board (CAB) safety regulations,
   - state of the art film processing, and
   - current USGS calibration report (within the past three years) meeting specifications for focal length (153 mm, ±3.0) and aerial weighted average resolution (AWAR of 100+ mm/inch).

B. Fully Analytical Aerotriangulation (FAAT)

FAAT is the process that merges the GPS control with the aerial photography. This process establishes a project-wide coordinate system for the photogrammetrist. FAAT specifications are as follows:

1. Fully analytical aerotriangulation (FAAT) for densifying the ABGPS control shall be accomplished by either conventional or digital methods;

2. Individual FAAT solutions shall be completed for theaerial photography; and

3. The final results of the FAAT shall be delivered to LANL.

C. Survey Controls

Survey controls shall be utilized so that the LIDAR and aerial photography can be "referenced/tied" to a known coordinate system. When available, contractor shall utilize the control points established by LANL on previous projects. The following survey controls shall be utilized:

1. Contractor shall use GPS technology to survey positions that will be used for the checkpoints supporting all mapping products. These points are used to verify the positional accuracy (horizontal and vertical) of the databases;

2. When applicable, contractor shall install a semi-permanent monument for each of the photo-control points. The monument shall be a #5 rebar, 24" long with an aluminum cap (LANL shall provide the survey cap). Additionally, a pre-mark shall be placed so that the control point will be visible in the aerial photography;

3. Horizontal coordinates shall be based on the New Mexico State Plane Coordinate System, North American Datum 1983. Elevations shall be based on National Geodetic Vertical Datum of 1988;

4. Upon completion of the survey an ARC/INFO coverage all the GPS points shall be provided to LANL; and

5. Airborne Global Positioning System (ABGPS) shall be used for the 1"=2,000' aerial photography and to support the LIDAR acquisition.

D. LIDAR Elevation Mapping

LIDAR (Light Detection And Ranging) is a proven radar technology used for collecting elevation data (x, y, z). There are two resolutions of LIDAR data being requested; Approximately 173 square miles of Low resolution LIDAR in Areas A & C (see map), and approximately 148 square miles of High resolution LIDAR in Area B (see attached map).

1. The following are the key data collection specifications for the Low resolution (1"= 400') LIDAR mission:

   a. The flying altitude of the aircraft shall be approximately 6,500 feet above mean ground level;

   b. The average DEM spot spacing shall not exceed 4';

   c. There shall be two GPS base stations on the ground during the LIDAR missions;

   d. The Low resolution LIDAR DEM shall be suitable for generating 10' contours;

   e. In order to accelerate the analysis of potential flooding and drainage problems, the contractor shall acquire a low resolution Digital Elevation Model (DEM) using the LIDAR "Bald Earth" model. The LIDAR DEM shall also be used to create digital ortho imagery and 10' contours. The positional accuracy of this data shall be 2.5' vertical and 8' horizontal;

   f. The integrity of the elevation data shall be increased using a "first and last pulse" procedure, as well as, evaluating the "intensity" of each posting;

   g. The aircraft shall be equipped with GPS and inertial reference systems that accurately determine the attitude and position of the sensor;

   h. The positional accuracy of the final contour data shall comply with National Map Accuracy Standards;

   i. META data attributes shall be added to the LIDAR data; and

   j. Reflectance and canopy data shall be generated from the LIDAR data.

2. The following are the key data collection specifications for the High Resolution (1" = 100') LIDAR mission:

   a. The flying altitude of the aircraft shall be approximately 3,000 feet above mean terrain. The flight lines shall be parallel with about a 40% side overlap. The sensor-scanning angle shall be approximately 30°. Based on the target acquisition speed or through the use of a helicopter, a ground point density of 1.56 feet along and perpendicular to the flight path shall be obtained. As needed, the contractor shall acquire LIDAR profiles in order to maintain vertical accuracy in specific areas of the project;

   b. There shall be two GPS base stations on the ground during the LIDAR missions;

c. The High resolution LIDAR DEM shall be suitable for generating 2' contours;

d. In order to accelerate the analysis of potential flooding and drainage problems, the contractor shall acquire a high resolution Digital Elevation Model (DEM) using the LIDAR "Bald Earth" model. The LIDAR DEM shall be suitable for creating digital ortho imagery and 2' contours. The positional accuracy of this data shall be 15 cm (0.5') vertical and 1' horizontal;

e. The integrity of the elevation data shall be increased using a "first and last pulse" procedure, as well as, evaluating the "intensity" of each posting;

f. The aircraft shall be equipped with GPS and inertial reference systems that accurately determine the attitude and position of the sensor;

g. The positional accuracy of the final contour data shall comply with National Map Accuracy Standards;

h. META data attributes shall be added to the LIDAR data; and

i. Reflectance and canopy data shall be generated from the LIDAR data.

E. Color Digital Orthophoto Production

A digital ortho image shall be produced that uses survey control, FAAT, and LIDAR DEM (low and high-resolution data) to correct distortions inherent with aerial photography. The color ortho imagery will cover all three study areas (A, B, C). The following specifications shall apply:

1. Contractor shall utilize digital mosaic technologies to create a "seamless" image database across the entire project. Contractor shall ensure that ground features on the digital ortho imagery shall edgematch within the specified National Map accuracy for each scale of photography. Tonal matching between different scale and dates of photography shall be accomplished to the best of the contractor's ability.

2. Contractor shall deliver the digital orthophoto in a TIFF (with a world file) format at a 2' pixel resolution covering an area 8,000' x 12,000', compatible with ARC/INFO. The imagery will also be compressed using MrSID.

3. The low and high resolution LIDAR elevation data shall be used to control the 1"=400' color digital orthos;

IV. Deliverable Products and Databases

The following describes the products and databases requested by LANL.

Aerial Photography Products

1. One (1) set of labeled (titled) original 9" x 9" color negatives of the aerial photography. The film will be delivered in an ASPRS approved canister.

2. Four (4) set of paper color 9" x 9" contact prints. One (1) set will be a "working" set used by the contractor. The remaining sets will be provided to LANL.

3. USGS certified Aerial Camera Calibration Report.

4. ARC/INFO point coverage of the ABGPS photo-centers.

Fully Analytical Aerotriangulation (FAAT) Products

1. Two (2) copies of the FAAT results and computations in a report form (both paper and electronic in WORD).

ARC/INFO Database Design and Definition

1. ARC/INFO database design documentation (both paper and electronic in WORD).

LIDAR Data Products

1. Two (2) sets of CD's Bald Earth LIDAR data in an ARC/INFO compatible ASCII file.

2. Two (2) sets of raw LIDAR data (i.e., filtered, uninterpolated, canopy and ground surface xyz points).

3. Two (2) sets of post-processed canopy data and reflectance imagery will be delivered.

4. Two (2) sets of the post-processed "Bald Earth" LIDAR data shall be delivered in an IEEE floating point (binary) format in column/row format suitable for input into ARC/INFO through the FLOATGRID command. This LIDAR dataset shall be delivered as an interpolated 1-foot grid. This product can optionally be deleted from the set of project deliverables at a cost savings to LANL of $18,000.

Digital Ortho Data Products

1. Two (2) sets of CD's for the 1"=400' color digital ortho imagery in a TIFF format at a 2.0' pixel resolution in the study areas. There are approximately 131 tiles in the 1"=400' study areas. Partial tiles of data are acceptable on the edge of the study area.s This delivery shall be uncompressed.

2. Two (2) sets of CD's for the 1"=400' color digital ortho imagery in a MrSID compressed format.

3. Eight (8) color wall mosaics of the digital ortho imagery. Each color mosaic will be in 2 pieces, approximately 48" x 72". The mosaics will be printed on color paper, mounted, and delivered.

4. Digital file for the color wall mosaics (Item #3 above).

V. Project Information Provided By LANL

1. Coordination with air traffic control to expedite the aerial photography and LIDAR missions.
2. Access (and escorts, if needed) to any areas where GPS control is needed for the LIDAR and photography missions.
3. Assistance with the design of the ARC/INFO coverage definition.
4. Provide the exact coordinates of the 1"=400' tile limits.
5. If applicable, provide subcontractor with the survey cap for the semi-permanent monument that is being installed during the survey task.
6. Brass cap database and survey records from previous flight.

VI. Schedule of Deliveries

The following summarizes the delivery schedule the requested products:

Finalize scope of work	June 7, 2000
Notice to proceed	June 9, 2000
GPS surveyors mobilize to project	June 12, 2000
Flight and LIDAR Plan to LANL	June 13, 2000
Aerial and LIDAR missions	June 19-July 10, 2000
1"=400' digital ortho, LIDAR data	60 days following field acquisition

VII. Laboratory Implementation Requirements (LIRs)

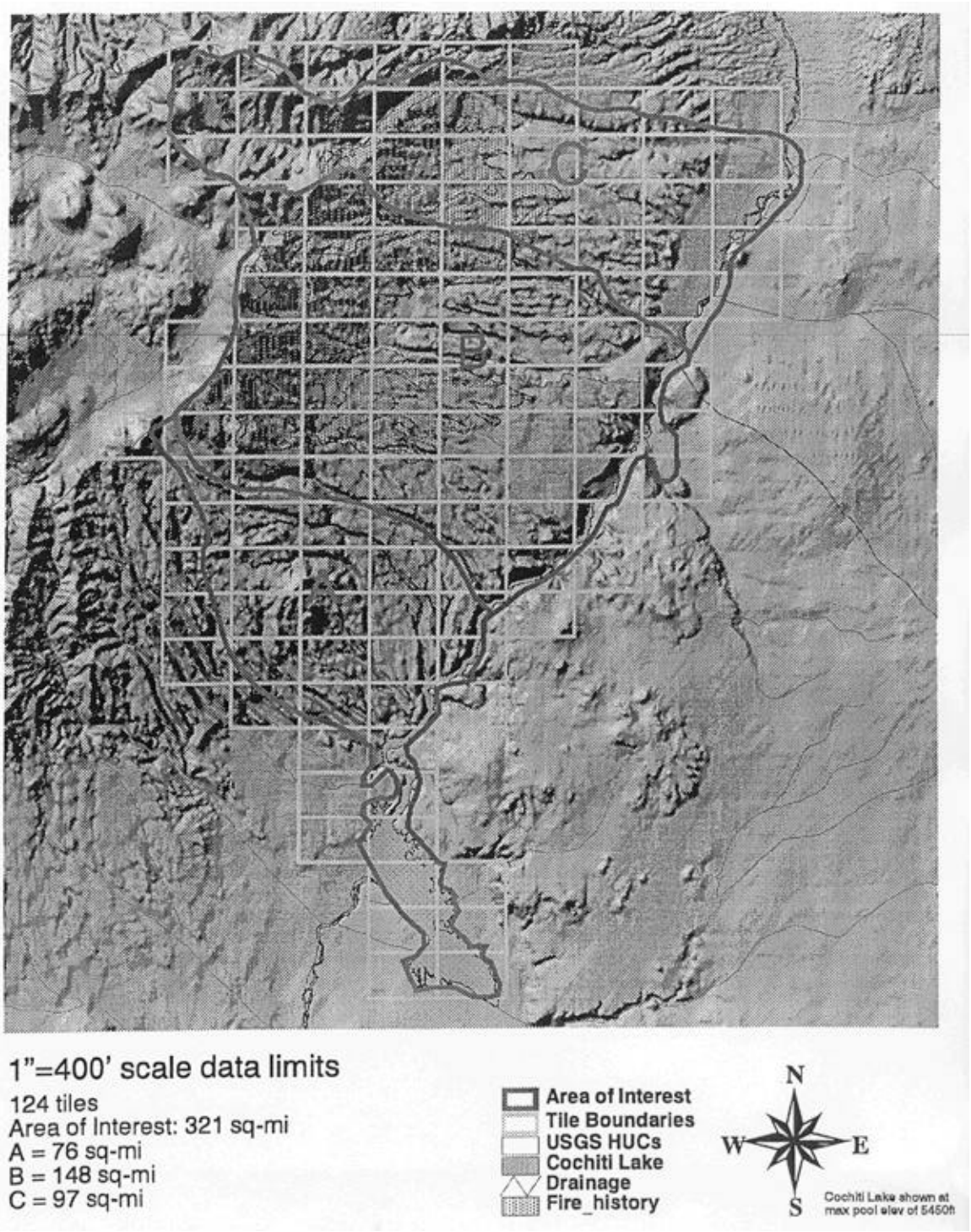
The contractor shall comply with all of the applicable requirements of the *Aviation Safety* LIR (LIR 402-1320-02.0).

VIII. Additional Comments

1. LANL encourages the submittal of products as they become available (e.g., as sub-regions are completed). This will help insure that the deliverables are in the required format and will help LANL conduct analysis of the fire effects in a timely manner.
2. File formats of deliverables may be changed upon mutual agreement of LANL and subcontractor.
3. The total area of the work (i.e., A, B, and C) is subject to minor adjustment (by <1% of the area).

IX. Confidential and Proprietary Information

Each party will treat as confidential all Information that has been or may hereafter be made available to the other in connection with this agreement. Except as necessary for the project, each party agrees that under no circumstance will it make use of or disclose the Information to any third party.


1"=400' scale data limits
124 tiles
Area of Interest: 321 sq-mi
A = 76 sq-mi
B = 148 sq-mi
C = 97 sq-mi
Area of Interest
Tile Boundaries
USGS HUCs
Cochiti Lake
Drainage
Fire_history
N
W
E
S
Cochiti Lake shown at max pool elev of 5450ft

APPENDIX II

Fully Analytical Aerotriangulation Report

Cerro Grande Fire
Fully Analytical Aerotriangulation Report

November 17th, 2000

Submitted to:

Mr. Robert Beers
LANL ESH-18
Los Alamos, NM 87545

Phone: 505-667-7969

Prepared by:

MERRICK & COMPANY
GIS, Survey, Photogrammetry Services
2450 South Peoria Street
Aurora, Colorado 80014

AEROTRIANGULATION REPORT

CERRO GRANDE FIRE

Los Alamos National Laboratory
ESH-18, ER, FIMAD

PHOTO SCALE: 1"=2000'

PHOTO DATE: June 14th, 2000

Prepared By: Merrick & Company
2450 S. Peoria Street
Aurora, Colorado 80014
(303) 751-0741

Project Manager: Brian Raber

CERRO GRANDE FIRE

FULLY ANALYTICAL AEROTRIANGULATION (FAAT) NARRATIVE

Negative Scale: 1"=2000'

1.1 Introduction

The Fully Analytical Aerotriangulation (FAAT) process calculates the exterior orientation for each camera station (x,y,z location at the photo center and tip, tilt and swing of the camera at the instant the photo was captured). This exterior orientation data is used in the digital ortho rectification process. FAAT also generates horizontal and vertical coordinates for supplemental photogrammetric points. These points are used for the absolute orientation of the stereo models in the compilation phase. FAAT simultaneously corrects image displacement caused by earth curvature, atmospheric refraction, camera lens distortion and aircraft (flight) inconsistencies.

This report summarizes the final results of the FAAT exercise and validates the Airborne GPS control and the field GPS survey control. The contents of this report include the following:

1. A narrative summarizing results and significant steps influencing the FAAT solution.

2. Root Mean Squared (RMS) error and residuals of the Airborne GPS.
   Table 1

3. Root Mean Squared (RMS) error and residuals of the final block adjustment of the surveyed ground control.
   Table 2

4. Camera calibration report.

4. Diagram of stereo model layout with survey points, photo centers and tiles.

1.2 Summary of the Process

This FAAT Report summarizes the aerotriangulation performed on color aerial photography covering the Cerro Grande Fire project area. The photography covering the aerotriangulation area consists of twelve (12) 1"=2000' scale flight lines. Aerial Surveys, Int'l., LLC captured the photography with a Jena LMK 2015 precision mapping camera and simultaneously collected Airborne GPS data (photo center xyz) for each exposure.

Merrick scanned the resulting aerial film negatives to produce one set of digital images for digital A/T processing. One set of working prints and three sets of client prints were made from the negatives as well.

Each control point was identified, numbered and marked directly on the working set of contact prints. A unique numeral identifies each point.

Merrick imported the scanned images, the Airborne GPS photo center data, the surveyed ground control data and the camera calibration data into our Socet Set and Orima A/T software. Interior orientation (the location of each fiducial is measured and compared to the camera calibration report's value for each fiducial) was performed on each image. We chose analytical points to act as passpoints from image to image and tie points from line to line. This process is automatic but closely supervised by an A/T Technician, and is augmented with manually placed points where the automatic point generation skips an area or places a point inaccurately. Adjustments are done strip by strip and when the errors and blunders are corrected the strips are tied together. Once the photogrammetry is complete and error free, we measure the ground control points. A simultaneous bundle adjustment is then performed, trouble shooted and reperformed until a satisfactory run is obtained

A total of forty-seven (47) GPS surveyed ground control points were used in the final FAAT solution. These ground control points were used in the FAAT solution as follows: Thirty-three (33) were used as vertical-only control and fourteen (14) were used as horizontal and vertical control. A detailed report concerning the surveyed ground control can be found at the beginning of Table 2, RMS Errors and Residuals for Final Solution Surveyed Ground Control. Airborne GPS photo control provided photo center x,y,z coordinates for each exposure. These ABGPS photo centers were held as horizontal and vertical control in the final FAAT solution.

The following table summarizes the total parameters for the Cerro Grande Fire project:

Exposures	Cntrl. Pts.	Photo Scale
165	47	1"=2000'

1.3 FAAT Equipment (hardware and software)

Merrick uses L H Systems Socet Set and Orima software to process the digital imagery and to perform Fully Analytical Digital Aerotriangulation.

1.4 FAAT Acceptance Criteria

The quality assurance check is performed by comparing the Airborne GPS control point results with the ground base GPS control point results. The results confirm that the solution is accurate.

The following table summarizes the accepted 1"=2000' FAAT results for the ground GPS (block RMS):

	X-Coordinate	*Y-Coordinate*	*Z-Coordinate*
RMSE	.9891	.7910	.3697

The following table summarizes the accepted 1"=2000' FAAT solution for the Airborne GPS photo centers:

	X-Coordinate	*Y-Coordinate*	*Z-Coordinate*
RMSE	1.120	1.162	.823

1.5 System Parameters

The final FAAT results are based on the following:

Cerro Grande Fire

Horizontal datum:	NAD-83 (rev. 1992) New Mexico State Plane, Central Zone
Vertical datum:	NGVD-29
Units:	US Survey Feet

Inspected by:

David Q. Pierson
Photogrammetric Technician
Merrick & Company

Juan Carlos Sanchez
Certified Photogrammetrist
Merrick & Company

Brian Raber
Project Manager and Mapping Scientist
Merrick & Company

Date Prepared: November 22nd, 2000

Table 1

AIRBORNE GPS
RMS ERROR & RESIDUALS

*** CAP Combined Adjustment Program *** Rel. 5.52 (C) L. Hinsken 1988-2000

User license: 946F19C4

Start of execution : 2000- 9-18 13:50:22

Adjusted GPS observations

Antenna centers

Ima./Prof.ID		Observations	SD.Post	SD.Prio	Resid.	Test	Redun	Reliab
1_05	X	1576006.460	1.511	2.000	-0.978	-0.2	0.38	13.99
1	Y	1766149.610	1.203	1.450	2.534	0.8	0.25	12.46
	Z	22010.960	0.804	1.200	1.736	0.5	0.51	7.23
1_04	X	1576152.220	1.523	2.000	0.628	-0.1	0.37	14.18
1	Y	1758939.660	1.182	1.450	-1.845	-0.6	0.28	11.87
	Z	21991.400	0.718	1.200	0.457	0.1	0.61	6.62
1_03	X	1576062.860	1.676	2.000	0.202	0.0	0.24	17.72
1	Y	1751749.810	1.241	1.450	1.611	0.6	0.20	13.85
	Z	21986.480	0.802	1.200	-1.564	-0.4	0.51	7.22
2_10	X	1587985.660	1.730	2.000	-0.617	-0.2	0.19	19.92
1	Y	1715454.080	1.325	1.450	-0.693	-0.4	0.09	20.57
	Z	21924.700	0.959	1.200	0.567	0.2	0.31	9.35
2_11	X	1587972.110	1.610	2.000	0.133	0.0	0.30	15.86
1	Y	1722631.470	1.246	1.450	-0.025	0.0	0.20	14.06
	Z	21963.710	0.789	1.200	0.045	0.0	0.53	7.11
2_12	X	1587980.800	1.722	2.000	1.042	0.3	0.19	19.54
1	Y	1729856.130	1.343	1.450	-0.203	-0.1	0.07	24.04
	Z	21985.070	0.939	1.200	-1.637	-0.5	0.34	8.94
2_13	X	1588038.070	1.684	2.000	-2.090	-0.5	0.23	17.97
1	Y	1737036.270	1.296	1.450	-1.587	-0.7	0.13	17.23
	Z	22006.880	0.840	1.200	-0.008	0.0	0.47	7.57
2_14	X	1587957.510	1.471	2.000	-0.317	-0.1	0.41	13.43
1	Y	1744244.830	1.146	1.450	-0.318	-0.1	0.32	11.04
	Z	21989.040	0.668	1.200	0.753	0.2	0.66	6.35
2_15	X	1587943.300	1.294	2.000	1.383	0.2	0.54	11.68
1	Y	1751454.430	1.046	1.450	-0.044	0.0	0.43	9.48
	Z	21960.120	0.579	1.200	-0.582	-0.1	0.75	5.99
2_16	X	1587997.180	1.198	2.000	1.364	0.2	0.61	11.04
1	Y	1758643.760	1.059	1.450	-0.724	-0.2	0.42	9.64
	Z	21894.680	0.566	1.200	-1.136	-0.3	0.76	5.94
2_17	X	1588002.100	1.211	2.000	-1.415	-0.2	0.60	11.12
1	Y	1765839.700	0.979	1.450	0.236	0.1	0.51	8.80
	Z	21882.360	0.560	1.200	0.154	0.0	0.76	5.92
2_18	X	1588046.170	1.281	2.000	0.505	0.1	0.55	11.60
1	Y	1773057.820	1.132	1.450	-1.536	-0.4	0.34	10.75
	Z	21971.880	0.623	1.200	-1.099	-0.3	0.71	6.16
2_19	X	1587993.330	1.491	2.000	0.544	0.1	0.40	13.71
1	Y	1780269.370	1.215	1.450	-0.022	0.0	0.24	12.83
	Z	21969.210	0.806	1.200	-1.117	-0.3	0.51	7.25
2_22	X	1588011.710	1.657	2.000	0.747	0.2	0.25	17.12
1	Y	1801853.780	1.298	1.450	-0.437	-0.2	0.13	17.34
	Z	21884.350	0.900	1.200	1.630	0.5	0.39	8.30
2_23	X	1587976.540	1.606	2.000	-1.981	-0.4	0.30	15.76
1	Y	1809030.230	1.268	1.450	-0.386	-0.2	0.17	15.21
	Z	21860.770	0.857	1.200	-0.550	-0.2	0.45	7.75
2_24	X	1588092.550	1.617	2.000	-1.818	-0.4	0.29	16.02
1	Y	1816268.870	1.276	1.450	-0.993	-0.4	0.16	15.72
	Z	22034.470	0.872	1.200	0.830	0.2	0.43	7.93

2_25	X	1588006.530	1.519	2.000	-0.135	0.0	0.37	14.11
1	Y	1823426.590	1.154	1.450	0.015	0.0	0.31	11.20
	Z	22124.010	0.700	1.200	-0.020	0.0	0.63	6.52
2_26	X	1587929.630	1.660	2.000	-0.193	0.0	0.25	17.20
1	Y	1830641.460	1.232	1.450	0.891	0.3	0.22	13.48
	Z	22176.910	0.932	1.200	-0.737	-0.2	0.34	8.81
3_24	X	1599982.710	1.614	2.000	0.011	0.0	0.29	15.94
1	Y	1830056.020	1.284	1.450	-0.790	-0.3	0.15	16.25
	Z	22557.830	0.982	1.200	0.199	0.1	0.41	8.06
3_23	X	1599908.080	1.578	2.000	-1.344	-0.3	0.32	15.17
1	Y	1822927.100	1.265	1.450	0.476	0.2	0.17	15.04
	Z	22537.550	0.850	1.200	0.147	0.0	0.46	7.67
3_22	X	1599959.000	1.723	2.000	-0.322	-0.1	0.19	19.59
1	Y	1815721.620	1.347	1.450	0.200	0.1	0.06	25.12
	Z	22513.920	0.842	1.200	-1.280	-0.4	0.47	7.59
3_21	X	1599954.500	1.887	2.000	-0.304	-0.2	0.03	47.39
1	Y	1808557.980	1.385	1.450	0.321	0.5	0.01	66.76
	Z	22500.840	1.097	1.200	-0.115	-0.1	0.09	17.05
3_20	X	1599931.350	1.744	2.000	-2.617	-0.7	0.17	20.69
1	Y	1801113.450	1.283	1.450	0.348	0.1	0.15	16.20
	Z	22489.420	0.974	1.200	-0.685	-0.2	0.28	9.70
3_19	X	1600008.980	1.682	2.000	-0.392	-0.1	0.23	17.94
1	Y	1793926.480	1.322	1.450	-0.412	-0.2	0.10	20.13
	Z	22496.160	0.861	1.200	-0.478	-0.1	0.44	7.79
3_18	X	1600025.070	1.471	2.000	-1.154	-0.2	0.41	13.43
1	Y	1786670.100	1.233	1.450	0.365	0.1	0.21	13.51
	Z	22498.830	0.750	1.200	0.578	0.1	0.58	6.82
3_17	X	1600045.780	1.439	2.000	0.802	0.1	0.44	13.04
1	Y	1779284.340	1.171	1.450	1.929	0.6	0.29	11.59
	Z	22473.830	0.731	1.200	0.140	0.0	0.60	6.70
3_16	X	1600085.790	1.277	2.000	0.769	0.1	0.56	11.56
1	Y	1771990.570	1.082	1.450	0.556	0.1	0.39	9.96
	Z	22494.360	0.615	1.200	1.143	0.3	0.71	6.12
3_15	X	1600093.520	1.401	2.000	-1.017	-0.2	0.47	12.62
1	Y	1764671.540	1.121	1.450	1.649	0.4	0.35	10.56
	Z	22523.620	0.663	1.200	0.712	0.2	0.67	5.33
3_14	X	1600027.750	1.259	2.000	1.427	0.2	0.57	11.43
1	Y	1756729.840	1.081	1.450	0.961	0.2	0.40	9.94
	Z	22564.330	0.624	1.200	0.885	0.2	0.71	6.16
3_13	X	1599981.260	1.336	2.000	1.472	0.2	0.52	12.02
1	Y	1748433.680	1.151	1.450	0.702	0.2	0.32	11.12
	Z	22554.990	0.649	1.200	0.166	0.0	0.68	6.27
3_12	X	1599990.060	1.385	2.000	2.483	0.4	0.48	12.46
1	Y	1739832.450	1.150	1.450	-0.583	-0.2	0.32	11.11
	Z	22562.830	0.645	1.200	-0.318	-0.1	0.69	6.25
3_11	X	1600042.880	1.503	2.000	-1.795	-0.3	0.39	13.87
1	Y	1731138.930	1.204	1.450	1.415	0.5	0.25	12.49
	Z	22541.050	0.733	1.200	0.791	0.2	0.59	6.71
3_10	X	1600048.210	1.519	2.000	1.754	0.3	0.37	14.11
1	Y	1723177.960	1.171	1.450	0.816	0.2	0.29	11.59
	Z	22529.600	0.692	1.200	0.373	0.1	0.64	6.48
3_09	X	1599973.840	1.577	2.000	0.346	0.1	0.32	15.14
1	Y	1714512.460	1.219	1.450	1.595	0.5	0.23	12.98
	Z	22541.040	0.740	1.200	0.286	0.1	0.59	6.75
3_08	X	1599940.250	1.831	2.000	0.355	0.1	0.09	28.89
1	Y	1705424.870	1.357	1.450	-0.314	-0.2	0.05	28.34
	Z	22510.650	0.963	1.200	-2.017	-0.7	0.30	9.44
4_03	X	1612038.670	1.665	2.000	0.353	0.1	0.25	17.36

1	Y	1662281.700	1.263	1.450	-1.339	-0.5	0.18	14.93
	Z	21991.390	0.933	1.200	-0.496	-0.2	0.34	8.84
4_04	X	1612042.070	1.571	2.000	0.651	0.1	0.33	15.02
1	Y	1671641.350	1.177	1.450	0.490	0.1	0.28	11.73
	Z	21983.350	0.737	1.200	0.718	0.2	0.59	6.73
4_05	X	1611998.920	1.691	2.000	-0.718	-0.2	0.22	18.25
1	Y	1680821.820	1.288	1.450	-0.017	0.0	0.14	16.53
	Z	22012.200	0.942	1.200	-1.247	-0.4	0.33	8.99
4_06	X	1611999.950	1.691	2.000	-1.044	-0.3	0.22	18.26
1	Y	1689928.830	1.314	1.450	-1.123	-0.5	0.11	19.03
	Z	22013.550	1.023	1.200	0.261	0.1	0.21	11.27
4_07	X	1611980.340	1.575	2.000	-0.256	-0.1	0.33	15.10
1	Y	1699219.550	1.218	1.450	-1.746	-0.6	0.23	12.93
	Z	22004.070	0.745	1.200	0.010	0.0	0.58	6.79
4_08	X	1611947.040	1.568	2.000	-0.781	-0.2	0.33	14.96
1	Y	1708109.890	1.173	1.450	-0.109	0.0	0.29	11.63
	Z	22006.580	0.736	1.200	0.596	0.1	0.59	6.73
4_09	X	1611937.270	1.588	2.000	-0.507	-0.1	0.32	15.36
1	Y	1717122.010	1.251	1.450	0.025	0.0	0.19	14.30
	Z	22004.560	0.872	1.200	0.100	0.0	0.43	7.92
4_10	X	1611994.620	1.511	2.000	-1.474	-0.3	0.38	14.00
1	Y	1725701.040	1.220	1.450	-1.949	-0.6	0.23	13.00
	Z	22025.350	0.771	1.200	-0.152	0.0	0.55	6.97
4_11	X	1611936.570	1.411	2.000	-1.002	-0.2	0.46	12.73
1	Y	1734012.870	1.126	1.450	-1.884	-0.5	0.34	10.65
	Z	21954.440	0.654	1.200	0.214	0.1	0.68	6.29
4_12	X	1611962.770	1.381	2.000	-2.666	-0.4	0.48	12.43
1	Y	1741849.440	1.079	1.450	-0.126	0.0	0.40	9.91
	Z	21966.620	0.626	1.200	0.700	0.2	0.70	6.17
4_13	X	1611982.640	1.479	2.000	-0.773	-0.1	0.41	13.54
1	Y	1750209.890	1.145	1.450	-0.180	-0.1	0.32	11.02
	Z	21955.990	0.656	1.200	0.689	0.2	0.68	6.30
4_14	X	1611981.390	1.444	2.000	-2.340	-0.4	0.43	13.09
1	Y	1758501.980	1.115	1.450	-1.491	-0.4	0.36	10.46
	Z	22009.590	0.638	1.200	0.660	0.2	0.69	6.22
4_15	X	1611919.510	1.499	2.000	-1.541	-0.3	0.39	13.82
1	Y	1766252.470	1.184	1.450	-2.574	-0.8	0.28	11.91
	Z	22018.520	0.727	1.200	-0.196	0.0	0.60	6.67
4_16	X	1611944.250	1.296	2.000	0.123	0.0	0.54	11.70
1	Y	1774173.830	1.060	1.450	-0.811	-0.2	0.42	9.66
	Z	22007.560	0.612	1.200	1.289	0.3	0.72	6.11
4_17	X	1611963.960	1.517	2.000	0.195	0.0	0.38	14.08
1	Y	1782112.710	1.226	1.450	-0.503	-0.2	0.22	13.25
	Z	22011.600	0.788	1.200	-0.999	-0.3	0.53	7.10
4_18	X	1611902.780	1.667	2.000	1.639	0.4	0.25	17.42
1	Y	1789541.040	1.354	1.450	-0.057	0.0	0.05	27.39
	Z	22020.550	1.062	1.200	-0.946	-0.5	0.15	13.39
4_19	X	1611988.870	1.782	2.000	-0.351	-0.1	0.14	23.25
1	Y	1797304.350	1.340	1.450	-0.357	-0.2	0.07	23.35
	Z	22000.690	1.082	1.200	0.312	0.2	0.12	15.10
4_20	X	1612013.430	1.771	2.000	0.627	0.2	0.15	22.44
1	Y	1804226.910	1.329	1.450	-0.606	-0.3	0.09	21.16
	Z	21950.240	0.939	1.200	-0.349	-0.1	0.34	8.94
4_21	X	1611970.310	1.735	2.000	-0.351	-0.1	0.18	20.17
1	Y	1811538.820	1.334	1.450	-0.314	-0.2	0.08	21.95
	Z	21945.640	0.833	1.200	-0.056	0.0	0.48	7.49
4_22	X	1612012.550	1.600	2.000	-0.828	-0.2	0.30	15.63
1	Y	1818161.940	1.206	1.450	-1.697	-0.5	0.25	12.54

	Z	21933.200	0.766	1.200	0.435	0.1	0.56	6.93
4_23	X	1611997.040	1.447	2.000	-0.474	-0.1	0.43	13.14
1	Y	1825359.340	1.227	1.450	-1.190	-0.4	0.22	13.27
	Z	21934.780	0.733	1.200	0.475	0.1	0.59	6.71
4_24	X	1612035.720	1.592	2.000	-0.130	0.0	0.32	15.24
1	Y	1832191.060	1.265	1.450	0.363	0.1	0.17	15.03
	Z	21925.780	0.881	1.200	-1.627	-0.5	0.41	8.04
5_24	X	1623983.210	1.645	2.000	-0.147	0.0	0.26	16.76
1	Y	1830309.070	1.300	1.450	-0.050	0.0	0.13	17.55
	Z	21270.260	0.924	1.200	-1.837	-0.6	0.36	8.68
5_23	X	1623920.890	1.538	2.000	-2.283	-0.4	0.36	14.43
1	Y	1822848.040	1.165	1.450	0.124	0.0	0.30	11.44
	Z	21285.130	0.755	1.200	-0.381	-0.1	0.57	6.85
5_22	X	1623972.650	1.555	2.000	-0.796	-0.2	0.34	14.72
1	Y	1815247.790	1.216	1.450	0.993	0.3	0.24	12.88
	Z	21308.480	0.717	1.200	0.470	0.1	0.61	6.62
5_21	X	1624016.160	1.700	2.000	1.102	0.3	0.22	18.59
1	Y	1807804.910	1.286	1.450	0.271	0.1	0.15	16.40
	Z	21341.960	0.896	1.200	0.685	0.2	0.39	8.25
5_20	X	1623915.000	1.544	2.000	-0.281	-0.1	0.35	14.52
1	Y	1800273.030	1.282	1.450	-0.130	-0.1	0.15	16.10
	Z	21375.490	0.917	1.200	0.021	0.0	0.37	8.56
5_19	X	1623948.610	1.363	2.000	-1.135	-0.2	0.50	12.25
1	Y	1792680.420	1.102	1.450	1.626	0.4	0.37	10.24
	Z	21303.700	0.712	1.200	1.226	0.3	0.52	6.59
5_18	X	1623960.820	1.345	2.000	0.590	0.1	0.51	12.10
1	Y	1785363.720	1.031	1.450	0.207	0.0	0.45	9.31
	Z	21319.100	0.623	1.200	-0.181	0.0	0.71	6.15
5_17	X	1624016.530	1.328	2.000	-1.646	-0.3	0.52	11.95
1	Y	1776999.470	1.068	1.450	-0.181	0.0	0.41	9.76
	Z	21347.890	0.605	1.200	-1.124	-0.3	0.72	6.08
5_16	X	1624063.750	1.667	2.000	-0.916	-0.2	0.25	17.40
1	Y	1769483.110	1.341	1.450	-0.249	-0.1	0.07	23.44
	Z	21296.980	0.951	1.200	0.073	0.0	0.32	9.19
5_15	X	1624084.500	1.340	2.000	0.502	0.1	0.51	12.05
1	Y	1761745.160	1.147	1.450	0.740	0.2	0.32	11.06
	Z	21291.090	0.614	1.200	-0.408	-0.1	0.72	6.12
5_14	X	1623985.650	1.256	2.000	0.445	0.1	0.57	11.41
1	Y	1754232.540	1.036	1.450	0.478	0.1	0.45	9.37
	Z	21295.310	0.580	1.200	0.344	0.1	0.75	5.99
5_13	X	1623903.560	1.216	2.000	-1.455	-0.2	0.60	11.15
1	Y	1746323.420	1.018	1.450	0.735	0.2	0.46	9.17
	Z	21276.650	0.545	1.200	0.494	0.1	0.78	5.89
5_12	X	1623922.550	1.218	2.000	0.057	0.0	0.60	11.16
1	Y	1738298.450	1.000	1.450	1.886	0.4	0.48	9.00
	Z	21314.660	0.558	1.200	-0.032	0.0	0.77	5.91
5_11	X	1624011.770	1.309	2.000	-0.821	-0.1	0.53	11.80
1	Y	1729682.990	1.122	1.450	0.032	0.0	0.35	10.57
	Z	21327.790	0.619	1.200	-0.920	-0.2	0.71	6.14
5_10	X	1624003.030	1.869	2.000	0.179	0.1	0.05	38.24
1	Y	1720828.370	1.350	1.450	-0.188	-0.1	0.06	26.02
	Z	21341.240	1.059	1.200	-0.361	-0.2	0.15	13.18
5_09	X	1623938.510	1.604	2.000	0.087	0.0	0.30	15.72
1	Y	1712667.820	1.228	1.450	1.845	0.6	0.22	13.32
	Z	21319.110	0.769	1.200	-0.913	-0.2	0.55	6.95
5_08	X	1623826.380	1.540	2.000	-1.190	-0.2	0.36	14.45
1	Y	1704120.500	1.141	1.450	0.570	0.2	0.33	10.92
	Z	21287.770	0.696	1.200	-0.280	-0.1	0.63	6.50

5_07	X	1624011.560	1.457	2.000	-0.954	-0.2	0.42	13.25
1	Y	1695609.170	1.189	1.450	0.625	0.2	0.27	12.05
	Z	21312.720	0.677	1.200	0.174	0.0	0.65	6.40
5_06	X	1623961.500	1.372	2.000	-0.872	-0.1	0.49	12.34
1	Y	1686772.860	1.142	1.450	0.174	0.0	0.33	10.96
	Z	21305.190	0.640	1.200	1.828	0.4	0.69	6.23
5_05	X	1623922.550	1.358	2.000	-1.172	-0.2	0.50	12.21
1	Y	1677956.900	1.080	1.450	1.921	0.5	0.40	9.92
	Z	21341.630	0.659	1.200	1.174	0.3	0.67	6.31
5_04	X	1623928.290	1.285	2.000	0.922	0.1	0.55	11.61
1	Y	1668355.740	1.041	1.450	0.815	0.2	0.44	9.43
	Z	21309.920	0.607	1.200	1.110	0.3	0.72	6.09
5_03	X	1623945.700	1.447	2.000	-1.672	-0.3	0.43	13.13
1	Y	1659857.470	1.159	1.450	-0.087	0.0	0.31	11.30
	Z	21351.440	0.802	1.200	-1.385	-0.4	0.52	7.21
10_05	X	1684013.410	1.658	2.000	0.272	0.1	0.25	17.12
1	Y	1778406.510	1.261	1.450	-1.577	-0.6	0.18	14.80
	Z	18036.340	0.961	1.200	0.084	0.0	0.30	9.40
10_06	X	1683915.490	1.588	2.000	0.025	0.0	0.32	15.36
1	Y	1784593.710	1.165	1.450	-0.098	0.0	0.30	11.45
	Z	18042.510	0.746	1.200	0.840	0.2	0.58	6.79
10_07	X	1683929.320	1.717	2.000	0.608	0.2	0.20	19.30
1	Y	1791890.150	1.257	1.450	0.369	0.1	0.18	14.60
	Z	18011.200	0.874	1.200	-1.774	-0.5	0.42	7.95
10_08	X	1683995.530	1.671	2.000	-1.375	-0.3	0.24	17.56
1	Y	1799171.060	1.304	1.450	-1.184	-0.5	0.12	17.99
	Z	18030.100	0.869	1.200	-0.588	-0.2	0.43	7.89
10_09	X	1684001.210	1.646	2.000	-0.830	-0.2	0.26	16.78
1	Y	1805918.550	1.262	1.450	-0.007	0.0	0.18	14.88
	Z	18003.190	0.771	1.200	0.549	0.1	0.55	6.97
10_10	X	1683939.450	1.520	2.000	-0.730	-0.1	0.37	14.13
1	Y	1812871.400	1.161	1.450	-1.155	-0.3	0.30	11.35
	Z	18020.070	0.689	1.200	0.623	0.2	0.64	6.46
10_11	X	1684031.520	1.418	2.000	-1.415	-0.2	0.45	12.80
1	Y	1819826.530	1.089	1.450	-0.938	-0.2	0.39	10.04
	Z	18016.900	0.642	1.200	0.454	0.1	0.69	6.23
10_12	X	1684078.320	1.565	2.000	-0.641	-0.1	0.34	14.90
1	Y	1825899.920	1.242	1.450	0.405	0.1	0.20	13.87
	Z	18018.650	0.817	1.200	-1.762	-0.5	0.50	7.34
7_28	X	1647979.530	1.340	2.000	-0.952	-0.2	0.51	12.05
1	Y	1830250.450	1.106	1.450	2.394	0.6	0.27	10.30
	Z	20102.100	0.789	1.200	-1.218	-0.3	0.53	7.10
7_27	X	1648046.510	1.206	2.000	-1.485	-0.2	0.60	11.09
1	Y	1823577.140	0.935	1.450	1.794	0.4	0.55	8.45
	Z	20104.180	0.558	1.200	0.141	0.0	0.77	5.92
7_26	X	1648076.020	1.018	2.000	2.206	0.3	0.72	10.17
1	Y	1816257.760	0.870	1.450	0.993	0.2	0.61	8.01
	Z	20135.760	0.460	1.200	0.503	0.1	0.84	5.64
7_25	X	1648034.970	1.072	2.000	1.223	0.2	0.69	10.40
1	Y	1809155.000	0.885	1.450	0.447	0.1	0.60	8.10
	Z	20144.860	0.491	1.200	0.648	0.1	0.82	5.72
7_24	X	1647993.290	1.053	2.000	0.824	0.1	0.70	10.32
1	Y	1801769.170	0.872	1.450	2.509	0.5	0.61	8.03
	Z	20142.660	0.479	1.200	0.299	0.1	0.83	5.69
7_23	X	1647958.070	1.112	2.000	2.915	0.4	0.66	10.58
1	Y	1794326.130	0.912	1.450	1.312	0.3	0.57	8.28
	Z	20148.090	0.492	1.200	0.470	0.1	0.82	5.73

7_22	X	1647960.080	1.148	2.000	-0.221	0.0	0.64	10.77
1	Y	1787041.260	0.932	1.450	1.615	0.3	0.55	8.42
	Z	20119.500	0.516	1.200	0.110	0.0	0.80	5.79
7_21	X	1647995.560	1.108	2.000	1.912	0.3	0.67	10.57
1	Y	1779683.630	0.924	1.450	2.034	0.4	0.56	8.36
	Z	20131.320	0.524	1.200	-0.164	0.0	0.79	5.81
7_20	X	1648039.950	1.148	2.000	0.445	0.1	0.64	10.76
1	Y	1772026.390	0.911	1.450	2.142	0.5	0.57	8.28
	Z	20158.400	0.533	1.200	0.059	0.0	0.79	5.84
7_19	X	1648040.150	1.016	2.000	1.722	0.2	0.71	10.25
1	Y	1764188.310	0.908	1.450	0.854	0.2	0.57	8.25
	Z	20157.560	0.491	1.200	-1.059	-0.2	0.82	5.72
7_18	X	1647978.600	1.054	2.000	1.382	0.2	0.70	10.32
1	Y	1756924.780	0.899	1.450	1.882	0.4	0.58	8.20
	Z	20154.850	0.459	1.200	-0.815	-0.2	0.84	5.64
7_17	X	1647918.510	1.033	2.000	1.403	0.2	0.71	10.24
1	Y	1749543.980	0.911	1.450	1.029	0.2	0.57	8.28
	Z	20133.940	0.455	1.200	-0.192	0.0	0.84	5.63
7_16	X	1647961.080	1.128	2.000	2.621	0.4	0.65	10.66
1	Y	1741860.850	0.981	1.450	1.657	0.4	0.50	8.82
	Z	20142.930	0.494	1.200	-0.826	-0.2	0.82	5.73
7_15	X	1648026.620	1.182	2.000	1.885	0.3	0.62	10.95
1	Y	1733914.620	1.012	1.450	1.931	0.5	0.47	9.12
	Z	20129.800	0.544	1.200	-0.295	-0.1	0.78	5.87
7_14	X	1647999.540	1.219	2.000	3.446	0.5	0.60	11.17
1	Y	1726661.800	1.051	1.450	0.187	0.0	0.43	9.54
	Z	20114.960	0.556	1.200	-0.247	-0.1	0.77	5.91
7_13	X	1648028.290	1.435	2.000	1.489	0.3	0.44	12.99
1	Y	1719326.660	1.168	1.450	-1.009	-0.3	0.29	11.52
	Z	20154.040	0.683	1.200	0.039	0.0	0.55	6.43
7_12	X	1648073.500	1.756	2.000	-0.462	-0.1	0.15	21.41
1	Y	1711805.170	1.326	1.450	-0.136	-0.1	0.09	20.63
	Z	20138.610	1.029	1.200	-0.235	-0.1	0.20	11.56
8_03	X	1659980.440	1.400	2.000	-0.316	-0.1	0.47	12.61
1	Y	1729625.730	1.122	1.450	-0.722	-0.2	0.35	10.58
	Z	19413.740	0.650	1.200	0.509	0.1	0.58	6.27
8_04	X	1659925.770	1.211	2.000	-0.423	-0.1	0.60	11.12
1	Y	1736374.170	0.963	1.450	-0.528	-0.1	0.52	8.66
	Z	19408.370	0.527	1.200	1.154	0.3	0.79	5.82
8_05	X	1659950.240	1.134	2.000	-1.092	-0.2	0.65	10.69
1	Y	1743678.660	0.942	1.450	-0.123	0.0	0.54	8.50
	Z	19393.490	0.483	1.200	0.731	0.2	0.82	5.70
8_06	X	1659985.590	1.197	2.000	-0.289	0.0	0.61	11.04
1	Y	1751110.480	1.029	1.450	0.090	0.0	0.45	9.30
	Z	19424.170	0.498	1.200	0.128	0.0	0.81	5.74
8_07	X	1659948.960	1.255	2.000	1.006	0.2	0.57	11.40
1	Y	1758517.410	0.990	1.450	-1.543	-0.4	0.49	8.90
	Z	19424.100	0.560	1.200	0.472	0.1	0.76	5.92
8_08	X	1659951.660	1.533	2.000	0.743	0.1	0.36	14.34
1	Y	1765740.100	1.155	1.450	1.963	0.6	0.31	11.22
	Z	19420.610	0.711	1.200	-0.753	-0.2	0.62	6.58
8_09	X	1660036.240	1.548	2.000	0.980	0.2	0.35	14.60
1	Y	1772758.170	1.165	1.450	-0.333	-0.1	0.30	11.44
	Z	19403.880	0.618	1.200	0.003	0.0	0.71	6.14
8_10	X	1659951.980	1.678	2.000	-0.667	-0.2	0.24	17.77
1	Y	1779782.220	1.169	1.450	0.072	0.0	0.29	11.53
	Z	19423.950	0.707	1.200	-0.060	0.0	0.62	6.56
8_11	X	1659961.450	1.657	2.000	1.297	0.3	0.25	17.09

1	Y	1786747.670	1.201	1.450	1.274	0.4	0.25	12.39
	Z	19411.720	0.794	1.200	-0.693	-0.2	0.52	7.15
8_12	X	1660032.770	1.383	2.000	1.857	0.3	0.48	12.44
1	Y	1793924.940	1.098	1.450	-2.133	-0.6	0.38	10.19
	Z	19393.690	0.617	1.200	0.844	0.2	0.71	6.13
8_13	X	1659912.270	1.337	2.000	0.468	0.1	0.51	12.03
1	Y	1801211.850	0.945	1.450	-0.905	-0.2	0.54	8.52
	Z	19383.420	0.553	1.200	1.133	0.2	0.77	5.90
8_14	X	1659957.240	1.533	2.000	-0.529	-0.1	0.36	14.34
1	Y	1808219.240	1.169	1.450	-0.373	-0.1	0.29	11.54
	Z	19405.010	0.635	1.200	-0.056	0.0	0.70	6.20
8_15	X	1659974.980	1.357	2.000	-0.569	-0.1	0.50	12.20
1	Y	1815499.620	1.072	1.450	-2.910	-0.7	0.41	9.81
	Z	19401.750	0.603	1.200	0.597	0.1	0.73	6.07
8_16	X	1660090.940	1.402	2.000	1.308	0.2	0.47	12.64
1	Y	1822435.220	1.092	1.450	-0.396	-0.1	0.38	10.09
	Z	19387.070	0.604	1.200	-0.114	0.0	0.72	6.08
8_17	X	1660197.220	1.691	2.000	0.846	0.2	0.22	18.24
1	Y	1829208.440	1.291	1.450	-0.123	-0.1	0.14	16.80
	Z	19362.080	0.851	1.200	-1.634	-0.5	0.45	7.68
6_25	X	1636000.320	1.343	2.000	-0.815	-0.1	0.51	12.08
1	Y	1830335.080	1.131	1.450	1.853	0.5	0.34	10.75
	Z	20792.400	0.800	1.200	-0.932	-0.3	0.52	7.20
6_24	X	1635996.870	1.227	2.000	1.623	0.2	0.59	11.22
1	Y	1823146.890	0.984	1.450	0.521	0.1	0.50	8.85
	Z	20793.780	0.554	1.200	-0.131	0.0	0.77	5.90
6_23	X	1636025.720	1.018	2.000	-0.951	-0.1	0.72	10.18
1	Y	1815418.530	0.925	1.450	-0.090	0.0	0.56	8.38
	Z	20780.040	0.474	1.200	1.367	0.3	0.83	5.68
6_22	X	1636055.360	1.117	2.000	-0.903	-0.1	0.66	10.61
1	Y	1807647.330	0.945	1.450	-1.145	-0.2	0.54	8.52
	Z	20806.430	0.512	1.200	0.551	0.1	0.80	5.78
6_21	X	1636059.940	1.097	2.000	-0.524	-0.1	0.67	10.51
1	Y	1799941.230	0.948	1.450	-0.624	-0.1	0.54	8.55
	Z	20809.890	0.501	1.200	-0.359	-0.1	0.81	5.75
6_20	X	1635995.850	1.062	2.000	-0.213	0.0	0.69	10.36
1	Y	1792440.070	0.914	1.450	2.142	0.5	0.57	8.30
	Z	20795.540	0.474	1.200	0.871	0.2	0.83	5.68
6_19	X	1636032.030	1.162	2.000	-0.111	0.0	0.63	10.84
1	Y	1784951.990	0.937	1.450	1.271	0.3	0.55	8.46
	Z	20795.110	0.483	1.200	-0.441	-0.1	0.82	5.70
6_18	X	1636068.140	1.075	2.000	0.564	0.1	0.69	10.41
1	Y	1777080.620	0.948	1.450	-0.106	0.0	0.54	8.54
	Z	20762.480	0.480	1.200	-0.349	-0.1	0.83	5.69
6_17	X	1635964.080	1.705	2.000	-0.986	-0.2	0.21	18.80
1	Y	1769518.640	1.327	1.450	0.416	0.2	0.09	20.77
	Z	20766.120	0.957	1.200	-0.864	-0.3	0.31	9.31
6_16	X	1635946.560	1.298	2.000	-0.066	0.0	0.54	11.71
1	Y	1761888.270	1.126	1.450	2.295	0.6	0.34	10.66
	Z	20784.040	0.666	1.200	-0.773	-0.2	0.67	6.34
6_15	X	1636034.310	1.142	2.000	1.009	0.1	0.65	10.73
1	Y	1753958.890	1.021	1.450	-0.014	0.0	0.46	9.22
	Z	20776.150	0.537	1.200	-0.204	0.0	0.78	5.85
6_14	X	1635957.060	1.080	2.000	1.593	0.2	0.68	10.44
1	Y	1746112.970	0.977	1.450	0.646	0.1	0.51	8.79
	Z	20804.660	0.497	1.200	-0.110	0.0	0.81	5.74
6_13	X	1635975.280	1.174	2.000	0.292	0.0	0.63	10.90
1	Y	1738067.910	1.034	1.450	0.334	0.1	0.45	9.35

	Z	20821.600	0.539	1.200	-0.551	-0.1	0.78	5.86
6_12	X	1635958.320	1.266	2.000	1.355	0.2	0.57	11.47
1	Y	1730205.160	1.077	1.450	0.612	0.2	0.40	9.88
	Z	20806.000	0.583	1.200	-1.240	-0.3	0.74	6.00
6_11	X	1635915.640	1.433	2.000	1.820	0.3	0.44	12.97
1	Y	1722136.540	1.172	1.450	0.874	0.7	0.29	11.60
	Z	20766.280	0.680	1.200	-1.079	-0.3	0.65	6.41
6_10	X	1635943.720	1.863	2.000	0.986	0.5	0.06	36.05
1	Y	1714014.450	1.334	1.450	0.665	0.4	0.08	22.04
	Z	20731.230	0.964	1.200	-0.799	-0.3	0.30	9.46
6_06	X	1636011.650	1.543	2.000	-0.169	0.0	0.35	14.51
1	Y	1682675.850	1.185	1.450	3.179	1.0	0.27	11.94
	Z	20761.550	0.935	1.200	-0.849	-0.3	0.34	8.88
6_05	X	1635986.050	1.381	2.000	1.071	0.2	0.48	12.42
1	Y	1674507.930	1.053	1.450	-0.061	0.0	0.43	9.57
	Z	20769.140	0.690	1.200	0.259	0.1	0.64	6.46
6_04	X	1636071.700	1.401	2.000	0.944	0.2	0.47	12.62
1	Y	1665858.800	1.144	1.450	-2.091	-0.6	0.32	11.00
	Z	20794.650	0.776	1.200	-0.863	-0.2	0.55	7.01
6_03	X	1635949.260	1.607	2.000	-0.525	-0.1	0.30	15.78
1	Y	1657560.340	1.289	1.450	-0.865	-0.4	0.14	16.63
	Z	20823.480	0.992	1.200	-1.552	-0.6	0.26	10.20
9_01	X	1671962.880	1.738	2.000	0.461	0.1	0.18	20.34
1	Y	1729982.510	1.286	1.450	-0.601	-0.3	0.15	16.39
	Z	18633.480	1.065	1.200	0.364	0.2	0.14	13.62
9_02	X	1672041.920	1.575	2.000	0.116	0.0	0.33	15.11
1	Y	1736293.790	1.230	1.450	-0.798	-0.3	0.22	13.37
	Z	18632.390	0.874	1.200	0.434	0.1	0.42	7.95
9_03	X	1671980.770	1.587	2.000	0.139	0.0	0.32	15.34
1	Y	1743122.230	1.232	1.450	-0.405	-0.1	0.22	13.47
	Z	18619.150	0.836	1.200	-0.426	-0.1	0.47	7.52
9_04	X	1671931.830	1.433	2.000	-0.487	-0.1	0.44	12.97
1	Y	1749886.800	1.206	1.450	-0.766	-0.2	0.25	12.53
	Z	18619.910	0.760	1.200	0.546	0.1	0.56	6.89
9_05	X	1672034.990	1.572	2.000	-0.517	-0.1	0.33	15.04
1	Y	1756843.470	1.260	1.450	-0.364	-0.1	0.18	14.74
	Z	18648.250	0.777	1.200	-0.788	-0.2	0.54	7.02
9_06	X	1672004.560	1.450	2.000	0.621	0.1	0.43	13.17
1	Y	1764164.500	1.139	1.450	-1.323	-0.4	0.33	10.88
	Z	18593.970	0.638	1.200	1.446	0.3	0.69	6.22
9_07	X	1672029.240	1.470	2.000	-0.121	0.0	0.41	13.42
1	Y	1770736.070	1.108	1.450	-2.483	-0.7	0.37	10.34
	Z	18586.530	0.652	1.200	0.115	0.0	0.68	6.28
9_08	X	1672037.600	1.541	2.000	-1.095	-0.2	0.35	14.48
1	Y	1777873.940	1.105	1.450	-1.082	-0.3	0.37	10.29
	Z	18581.660	0.634	1.200	0.108	0.0	0.70	6.20
9_09	X	1671953.480	1.490	2.000	1.234	0.2	0.40	13.70
1	Y	1785029.180	1.074	1.450	-1.078	-0.3	0.40	9.84
	Z	18603.870	0.604	1.200	0.242	0.1	0.73	6.08
9_10	X	1671971.210	1.490	2.000	-0.635	-0.1	0.40	13.69
1	Y	1791863.820	1.116	1.450	-2.140	-0.6	0.36	10.47
	Z	18621.610	0.624	1.200	-0.149	0.0	0.71	6.16
9_11	X	1672001.340	1.372	2.000	-0.389	-0.1	0.49	12.33
1	Y	1798848.280	1.105	1.450	-1.333	-0.4	0.37	10.30
	Z	18624.640	0.600	1.200	-0.156	0.0	0.73	6.06
9_12	X	1671966.010	1.246	2.000	-0.246	0.0	0.58	11.34
1	Y	1805535.260	1.008	1.450	-0.538	-0.1	0.48	9.07
	Z	18589.720	0.560	1.200	1.018	0.2	0.76	5.92

9_13	X	1672022.860	1.217	2.000	-0.698	-0.1	0.60	11.16
1	Y	1812449.600	0.968	1.450	-0.811	-0.2	0.52	8.71
	Z	18593.580	0.522	1.200	1.068	0.2	0.79	5.81
9_14	X	1672051.550	1.303	2.000	-1.102	0.2	0.54	11.75
1	Y	1818835.220	0.971	1.450	-0.318	-0.1	0.51	8.74
	Z	18586.600	0.545	1.200	0.086	0.0	0.78	5.88
9_15	X	1671960.720	1.500	2.000	0.328	0.1	0.39	13.84
1	Y	1825721.450	1.159	1.450	2.054	0.6	0.31	11.30
	Z	18601.830	0.763	1.200	-1.235	-0.3	0.56	6.91
11_12	X	1695977.190	1.833	2.000	-1.701	-0.7	0.09	29.10
1	Y	1820733.830	1.382	1.450	-0.503	-0.7	0.01	54.12
	Z	17628.900	1.054	1.200	-1.376	-0.7	0.16	12.89
11_11	X	1695924.430	1.798	2.000	-0.354	-0.1	0.12	24.71
1	Y	1814155.460	1.355	1.450	-0.923	-0.7	0.05	27.59
	Z	17623.050	0.941	1.200	-2.078	-0.7	0.33	8.99
11_10	X	1695879.710	1.692	2.000	-0.445	-0.1	0.22	18.28
1	Y	1807351.850	1.302	1.450	0.182	0.1	0.12	17.72
	Z	17622.070	0.820	1.200	1.703	0.5	0.49	7.37
11_09	X	1696007.150	1.701	2.000	-0.117	0.0	0.21	18.63
1	Y	1800873.100	1.316	1.450	1.318	0.7	0.10	19.32
	Z	17607.820	0.840	1.200	0.227	0.1	0.47	7.57
11_08	X	1696141.920	1.604	2.000	1.148	0.2	0.30	15.71
1	Y	1794484.220	1.271	1.450	1.856	0.7	0.16	15.40
	Z	17617.850	0.774	1.200	1.082	0.3	0.55	6.99
11_07	X	1696109.980	1.711	2.000	0.320	0.1	0.20	19.06
1	Y	1787796.800	1.305	1.450	1.110	0.5	0.12	18.05
	Z	17596.970	0.776	1.200	-0.012	0.0	0.55	7.00
11_06	X	1695992.910	1.797	2.000	-1.765	-0.6	0.12	24.59
1	Y	1781091.480	1.322	1.450	-0.226	-0.1	0.10	20.02
	Z	17613.210	1.027	1.200	-1.334	-0.6	0.20	11.45
12_09	X	1708012.300	1.706	2.000	0.548	0.1	0.21	18.86
1	Y	1799446.320	1.358	1.450	-0.931	-0.7	0.05	28.88
	Z	17003.350	0.993	1.200	0.163	0.1	0.26	10.23
12_10	X	1708096.250	1.522	2.000	0.032	0.0	0.37	14.17
1	Y	1805616.870	1.291	1.450	-0.998	-0.4	0.14	16.82
	Z	17034.190	0.795	1.200	-0.168	0.0	0.52	7.16
12_11	X	1707978.560	1.733	2.000	0.223	0.1	0.18	20.05
1	Y	1811825.170	1.334	1.450	0.738	0.4	0.08	21.96
	Z	17011.620	1.011	1.200	0.104	0.0	0.23	10.82

RMS-X: 1.120
RMS-Y: 1.162
RMS-Z: 0.823

Variance components for GPS observations

X: 0.84
Y: 1.40 Increase the standard deviation a priori
Z: 0.86

Mean terrain height: 7085.0

Table 2

FINAL SOLUTION
RMS ERROR & RESIDUALS-
SURVEYED GROUND CONTROL

The following table lists the surveyed ground control points used in the final adjustment. HVC refers to points that were used as horizontal and vertical control and VC refers to points that were used as vertical control only. The notes are self explanatory.

Pt #	Type	Notes
101	HVC	Panel found: Used horizontally and vertically.
200	HVC	Panel found: Used horizontally and vertically.
201	HVC	Panel found: Used horizontally and vertically.
202	HVC	Panel found: Used horizontally and vertically.
203	HVC	Panel found: Used horizontally and vertically.
204	HVC	Panel found: Used horizontally and vertically.
205	HVC	Panel found: Used horizontally and vertically.
206	HVC	Panel found: Used horizontally and vertically.
209	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
210	HVC	Panel found: Used horizontally and vertically.
215	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
216	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
217	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
218	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
219	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
220	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
221	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
222	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
223	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
225	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
226	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
227	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
228	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
229	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
231	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
232	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
233	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
234	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
304	HVC	Panel found: Used horizontally and vertically.
306	HVC	Panel found: Used horizontally and vertically.
309	HVC	Panel found: Used horizontally and vertically.
313	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
315	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
317	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
318	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
319	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
322	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
323	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
325	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
328	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
329	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
333	HVC	Panel found: Used horizontally and vertically.
334	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
335	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.
337	VC	Reflective LIDAR panel: 'Driven-to' and used vertically.

FINAL ADJUSTMENT

RMS Error and Residuals for Surveyed Ground Control

Control points

Point ID		Coordinates	SD.Post	SD.Prio	Resid.	Test	Redun	Int.Reli	Ext.Reli.
101	X	1627847.8194	0.4982	1.0000	0.0674	0.0	0.73	5.05	0.73
	Y	1775523.2023	0.5142	1.0000	-0.2937	-0.1	0.71	5.11	0.78
	Z	7251.7163	0.6403	1.0000	-0.1637	-0.1	0.55	5.79	0.76
200	X	1649421.2116	0.5581	1.0000	0.6426	0.2	0.66	5.30	1.16
	Y	1765207.9864	0.5481	1.0000	-1.2716	-0.4	0.67	5.25	1.46
	Z	6538.0052	0.7913	1.0000	-0.0548	0.0	0.32	7.63	1.77
201	X	1648971.1027	0.5362	1.0000	0.7067	0.2	0.69	5.20	1.18
	Y	1754880.1693	0.5345	1.0000	-0.2057	-0.1	0.69	5.19	1.58
	Z	6523.4454	0.7846	1.0000	0.4554	0.2	0.33	7.49	1.91
202	X	1645891.1088	0.4962	1.0000	-0.3702	-0.1	0.73	5.04	0.93
	Y	1751012.1000	0.4776	1.0000	-1.6030	-0.4	0.75	4.97	0.97
	Z	6447.1787	0.6839	1.0000	-0.5313	-0.2	0.49	6.15	1.18
203	X	1653308.6893	0.5840	1.0000	1.2313	0.4	0.63	5.44	1.11
	Y	1757069.6998	0.5430	1.0000	-0.4312	-0.1	0.68	5.23	1.35
	Z	6390.4349	0.7724	1.0000	0.7349	0.3	0.35	7.27	1.67
204	X	1654159.0338	0.4782	1.0000	0.6988	0.2	0.75	4.97	0.69
	Y	1748961.9374	0.4625	1.0000	-0.6666	-0.2	0.77	4.92	0.71
	Z	6338.7773	0.6320	1.0000	0.6273	0.2	0.57	5.73	0.70
205	X	1653029.2597	0.6425	1.0000	1.1487	0.4	0.55	5.81	1.56
	Y	1744074.2810	0.6105	1.0000	0.8600	0.3	0.60	5.59	1.84
	Z	6301.9468	0.8689	1.0000	0.7768	0.4	0.18	10.17	1.34
206	X	1658205.2049	0.6208	1.0000	-1.1051	-0.3	0.58	5.66	1.59
	Y	1755910.1430	0.6001	1.0000	0.6990	0.2	0.61	5.53	1.80
	Z	6299.8278	0.8881	1.0000	0.4778	0.3	0.14	11.40	1.47
209	X	1576088.3063	1.3238						3.08
	Y	1763854.7334	1.1762						3.68
	Z	8738.6172	0.9103	1.0000	0.2472	0.2	0.10	13.65	1.35
210	X	1589276.7388	0.7019	1.0000	0.1208	0.0	0.46	6.33	1.28
	Y	1763689.1803	0.6496	1.0000	-0.0677	0.0	0.54	5.86	1.67
	Z	8948.8472	0.8947	1.0000	0.3172	0.2	0.13	11.94	1.43
215	X	1665900.5707	1.1132						3.41
	Y	1777030.6407	0.9146						3.72
	Z	5676.7184	0.9146	1.0000	0.0084	0.0	0.09	14.28	1.30
216	X	1683445.9074	2.0178						3.79
	Y	1781007.1348	1.3462						5.08
	Z	5579.5313	0.9161	1.0000	0.0513	0.0	0.09	14.52	1.28
217	X	1690645.3321	1.9376						19.82
	Y	1814010.8974	1.3845						10.41
	Z	5588.9071	0.9437	1.0000	0.5371	0.7	0.03	23.91	0.78
218	X	1679855.8349	1.3127						3.58
	Y	1799870.9016	0.9753						5.22
	Z	5646.5167	0.9196	1.0000	0.0567	0.0	0.08	15.12	1.23
219	X	1667410.8325	0.9469						3.16
	Y	1804786.3101	0.8514						4.30
	Z	5419.0544	0.8884	1.0000	0.2844	0.2	0.14	11.42	1.63
220	X	1650474.0323	0.8400						3.02
	Y	1807676.6560	0.8010						3.58
	Z	6799.9029	0.8951	1.0000	0.1529	0.1	0.13	11.98	1.55

221	X 1687537.5023	1.6233						3.10
	Y 1826083.5634	1.2882						3.75
	Z 5734.6878	0.9146	1.0000	-0.0622	0.0	0.09	14.27	1.30
222	X 1637704.0014	0.8644						3.09
	Y 1812059.2348	0.8115						3.43
	Z 7020.1613	0.8954	1.0000	0.2213	0.1	0.13	12.01	1.55
223	X 1635537.4650	0.9067						3.12
	Y 1818064.0652	0.8702						3.88
	Z 7088.2724	0.8975	1.0000	0.7324	0.5	0.12	12.20	1.52
225	X 1611948.9670	1.2810						3.43
	Y 1810068.8597	1.2005						5.00
	Z 8130.2362	0.9214	1.0000	0.3662	0.3	0.08	15.46	1.19
226	X 1599685.5102	1.5305						3.57
	Y 1811186.6453	1.2186						4.73
	Z 8643.6751	0.9322	1.0000	0.6951	0.7	0.06	18.22	1.01
227	X 1681707.2853	1.3227						2.98
	Y 1822815.8661	1.0160						3.43
	Z 5866.0139	0.9007	1.0000	-0.0161	0.0	0.12	12.52	1.49
228	X 1655055.6625	1.1470						3.10
	Y 1822616.5501	1.1463						5.38
	Z 6746.5931	0.9140	1.0000	-0.0869	-0.1	0.09	14.18	1.31
229	X 1636834.3631	1.0476						2.93
	Y 1827507.5849	0.9165						3.43
	Z 8157.0492	0.8896	1.0000	0.3092	0.2	0.14	11.51	1.62
231	X 1595197.3812	1.8265						7.11
	Y 1826457.2888	1.1619						5.79
	Z 10945.9417	0.9049	1.0000	-0.1283	-0.1	0.11	12.97	1.41
232	X 1585056.8807	1.7016						2.77
	Y 1828564.8243	1.1762						3.89
	Z 10538.2429	0.8998	1.0000	0.5629	0.4	0.12	12.43	1.48
233	X 1613078.5070	1.3555						2.96
	Y 1830231.0667	1.0916						3.69
	Z 9264.3776	0.9057	1.0000	0.2576	0.2	0.11	13.97	1.40
234	X 1677446.3236	1.1303						3.16
	Y 1788664.6913	1.0706						3.55
	Z 5560.5739	0.9092	1.0000	-0.1261	-0.1	0.10	13.51	1.38
304	X 1630027.0016	0.4850	1.0000	-0.0734	0.0	0.74	5.00	0.69
	Y 1776254.8436	0.4983	1.0000	-0.5114	-0.1	0.73	5.05	0.67
	Z 7207.3636	0.6290	1.0000	-0.4364	-0.1	0.57	5.71	0.73
306	X 1634331.9427	0.5144	1.0000	-1.5433	-0.4	0.71	5.11	0.92
	Y 1775238.8446	0.5142	1.0000	-1.2404	-0.3	0.71	5.11	0.94
	Z 7134.9065	0.6842	1.0000	-0.5935	-0.2	0.49	5.15	1.23
309	X 1631733.5536	0.6441	1.0000	-1.5904	-0.5	0.55	5.82	1.58
	Y 1772176.9794	0.6214	1.0000	-0.0405	0.0	0.58	5.65	1.74
	Z 7061.4959	0.8783	1.0000	0.5559	0.3	0.16	10.71	1.32
313	X 1638244.7420	0.8255						3.29
	Y 1740934.9712	0.7971						3.68
	Z 6571.7605	0.9003	1.0000	-0.0695	0.0	0.12	12.48	1.49
315	X 1590846.3948	1.2687						3.22
	Y 1739517.3870	1.0747						3.95
	Z 8399.0679	0.9135	1.0000	-0.0621	0.0	0.09	14.11	1.31
317	X 1615975.1529	2.4236						4.10
	Y 1691420.7178	1.6735						5.99
	Z 5535.4353	0.9317	1.0000	-0.0247	0.0	0.06	18.06	1.02
318	X 1616547.7398	1.8134						4.21
	Y 1670052.2848	1.4090						6.26
	Z 5255.2614	0.9270	1.0000	0.2514	0.2	0.07	16.72	1.10
319	X 1625512.7178	1.5022						3.59

	Y 1666665.7173	1.3349						5.42
	Z 5479.6983	0.9205	1.0000	0.3583	0.3	0.08	15.10	1.22
322	X 1637626.3010	1.7139						3.62
	Y 1679549.2164	1.4847						4.17
	Z 5544.6677	0.9213	1.0000	0.3277	0.3	0.08	15.45	1.20
323	X 1657468.4944	1.1231						3.21
	Y 1727416.2357	0.9732						4.37
	Z 6544.4912	0.9054	1.0000	-0.2688	-0.2	0.11	13.04	1.42
325	X 1646860.6720	1.6622						5.45
	Y 1710420.4672	1.4315						4.56
	Z 6639.6664	0.9209	1.0000	-0.1136	-0.1	0.08	15.38	1.21
328	X 1665669.1483	1.0756						3.01
	Y 1821339.5263	0.8848						3.44
	Z 6613.1814	0.8984	1.0000	0.1114	0.1	0.12	12.29	1.51
329	X 1646692.8032	1.0025						3.05
	Y 1825659.3879	0.9250						3.74
	Z 7044.8267	0.9026	1.0000	0.1667	0.1	0.12	12.72	1.46
333	X 1598690.6824	0.8018	1.0000	1.3404	0.6	0.30	7.85	0.81
	Y 1827231.0410	0.7631	1.0000	-0.3930	-0.2	0.37	7.11	1.26
	Z 10649.1388	0.8845	1.0000	-0.2312	-0.1	0.15	11.13	1.53
334	X 1605863.1280	2.0782						4.02
	Y 1708298.7435	1.5413						5.34
	Z 5966.9997	0.9304	1.0000	0.2497	0.2	0.06	17.67	1.04
335	X 1593549.2531	1.7796						3.50
	Y 1719490.2834	1.3407						4.42
	Z 7331.8487	0.9255	1.0000	0.3287	0.3	0.07	16.36	1.13
337	X 1604422.2277	1.3367						2.38
	Y 1730955.8002	1.1562						2.88
	Z 8447.8633	0.8549	1.0000	0.1233	0.1	0.21	9.50	1.49

Maximum changes at control points:

```
X:     -1.6904    at Point ID.: 309
Y:     -1.6030    at Point ID.: 202
Z:      0.7768    at Point ID.: 205
```

RMS of changes at control points:

```
X:      0.9891
Y:      0.7910
Z:      0.3697
```

CAMERA CALIBRATION REPORT

USGS Report No. OSL/2521

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

February 1, 1999

Camera type: Jena LMK 2015*
Lens type: Jena Lamegon PI/E
Nominal focal length: 153 mm

Camera serial no.: 275842E
Lens serial no.: 275842E
Maximum aperture: f/4
Test aperture: f/4

Submitted by: Air Surveys International, LLC
Denver, Colorado

Reference: Air Surveys International, LLC, purchase order No. 029918AS, dated February 18, 1999.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type 157-01 Panchromatic, developed in D-19 at 68° F for 3 minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 5200K.

I. Calibrated Focal Length: 152.494 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	-1	-1	0	1	2	-2
Decentering (um)	0	0	1	1	1	2

Symmetric radial distortion parameters

$K_0 = 0.3584 \times 10^{-4}$
$K_1 = -0.1126 \times 10^{-7}$
$K_2 = 0.6015 \times 10^{-12}$
$K_3 = 0.0000$
$K_4 = 0.0000$

Decentering distortion parameters

$P_1 = 0.1135 \times 10^{-6}$
$P_2 = 0.4886 \times 10^{-7}$
$P_3 = 0.0000$
$P_4 = 0.0000$

Calibrated principal point

$x_p = 0.000$ mm
$y_p = -0.003$ mm

The values and parameters for Calibrated Focal Length (CFL), Symmetric Radial Distortion (K_0, K_1, K_2, K_3, K_4), Decentering Distortion (P_1, P_2, P_3, P_4), and Calibrated Principal Point (point of symmetry) (x_p, y_p) were determined through a least-squares Simultaneous Multiframe Analytical Calibration (SMAC) adjustment. The x and y-coordinate measurements utilized in the adjustment of the above parameters have a standard deviation (σ) of ±3 microns.

* Equipped with Forward Motion Compensation

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 109

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	134	134	134	113	113	95	113
Tangential lines	134	134	134	95	113	95	95

The resolving power is obtained by photographing a series of test bars and examining the resultant image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable confidence. The series of patterns has spatial frequencies from 5 to 268 cycles/mm in a geometric series having a ratio of the 4th root of 2. Radial lines are parallel to a radius from the center of the field, and tangential lines are perpendicular to a radius.

IV. Filter Parallelism

The two surfaces of the Jena 405 No. 51993, the 490 No. 275583, and the 530 No. 275580 filters accompanying this camera are within 10 seconds of being parallel. The 490 filter was used for the calibration.

V. Shutter Calibration

Indicated exposure time	Effective exposure time	Efficiency
1/125	10.00 ms = 1/100 s	71%
1/250	5.00 ms = 1/200 s	71%
1/500	2.40 ms ~ 1/415 s	71%
1/1000	1.20 ms ≈ 1/835 s	71%

The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Magazine Platen

The platens mounted in LMK-K 24/120 film magazines No. 271821 and No. 271902 do not depart from a true plane by more than 13 um (0.0005 in).

These film magazines are equipped with identification markers that will register "271821" for magazine No. 271821, and "271902" for magazine No. 271902 in the film edge for each exposure.

USGS Report No. OSL/2521

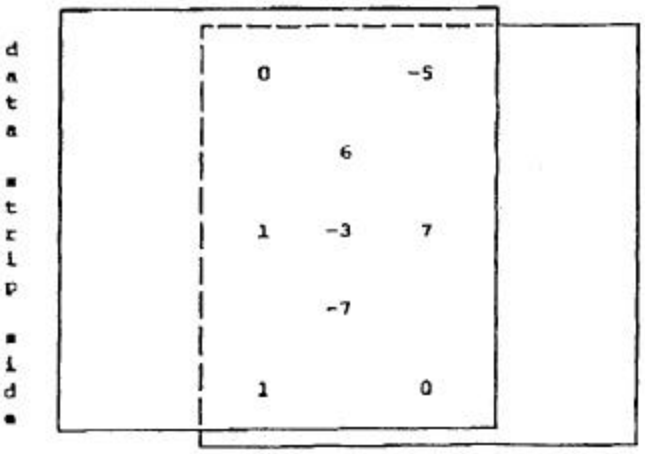
IX. Stereomodel Flatness

FMC Magazine No.: 271821

Platen ID: 271821

Base/Height ratio: 0.6

Maximum angle of field tested: 40°



Stereomodel
Test point array
(values in micrometers)

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 43

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	48	48	48	48	40	40
Tangential lines	57	48	48	40	40	40	34

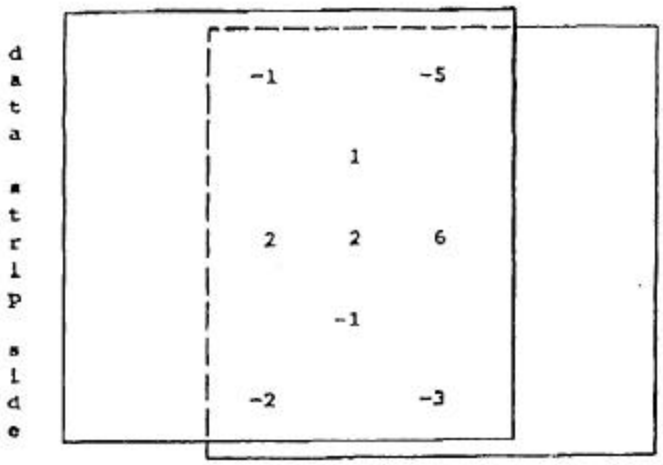
IX. Stereomodel Flatness

FMC Magazine No.: 271902

Platen ID: 271902

Base/Height ratio: 0.6

Maximum angle of field tested: 40°



Stereomodel
Test point array
(values in micrometers)

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.

X. Lens/Film Resolving Power in cycles/mm

Area-weighted average resolution: 44

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	57	48	48	40	40
Tangential lines	57	57	48	48	40	40	34

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2153, dated December 11, 1995.

Frank C. Maccue

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National Mapping Division